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Sonar Enumeration of Pacific Salmon Into Nushagak River and Evaluation of Species Composition Estimates, 1992

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ABSTRACT

Estimates of Pacific salmon *Oncorhynchus* escapement for the Nushagak River in Bristol Bay, Alaska, were determined by hydroacoustic procedures from June 9 through July 22, 1992. The escapement was sampled with drift gillnets and beach seines to estimate species composition, age, sex, and size. New methods used in 1992 to estimate species composition were evaluated and recommendations made. Final escapement estimates by species through July 22 were 695,108 sockeye salmon *O. nerka*, 82,848 chinook salmon *O. tshawytscha*, 302,678 chum salmon *O. keta*, and 8,600 pink salmon *O. gorbuscha*.

KEYWORDS: Pacific salmon, sonar, Nushagak River, Bristol Bay, escapement, estimation, fisheries management, *Oncorhynchus,* gillnet selectivity

INTRODUCTION

The Nushagak River is located in southwestern Alaska (Figure 1) and flows approximately 390 km from its headwaters into Nushagak Bay in Bristol Bay, Alaska. Two main tributaries — Nuyakuk River and Mulchatna River — converge to form the Nushagak River. These rivers support large populations of five species of Pacific salmon *Oncorhynchus* which are harvested in commercial, sport, and subsistence fisheries. Accurate escapement estimates into this system are essential to fishery management.

In 1979, the Alaska Department of Fish and Game (ADF&G) began to examine the feasibility of using hydroacoustic (sonar) equipment and procedures to count adult salmon in Nushagak River (McBride 1981). During subsequent years, the Nushagak River sonar project has provided information important to the management of commercial fishing in Nushagak District.

Estimating numbers of salmon migrating into Nushagak River with sonar involves (1) estimating the number of hydroacoustic targets passing through sonar beam(s), (2) estimating the species composition of those targets by sampling the escapement, and (3) combining estimates of hydroacoustic targets and species composition to estimate numbers of passing salmon by species. During the initial years of the project, many changes were incorporated into the sonar and escapement sampling methods (McBride and Mesiar 1981, 1982; Minard 1983, 1985; Minard and Frederickson 1983). Few changes have been made in sonar operations since 1985, but changes have been made in the escapement sampling methods through the years (Morstad and Minard 1986, 1988; Bue 1988a, 1988b; Woolington and Bue 1989; Woolington and Miller 1992). Brannian et al. (*in press*) evaluated escapement sampling and the associated species apportionment methods used on Nushagak River during 1991 and compared them with methods used on the Lower Yukon River. Based on their project review, new methods of estimating Nushagak River salmon passage by species were incorporated in 1992.

Project objectives in 1992 were to estimate the spawning escapements from early June through mid-August for all five salmon species. However, the project was terminated in late July due to budget shortfalls, and counts of pink salmon and coho salmon were inadequate. Therefore, the objectives of this report are to (1) estimate from early June through late July the spawning escapements for chinook, sockeye, and chum salmon, and (2) evaluate escapement sampling procedures and new species apportionment methods.

METHODS

The sonar enumeration site was located on Nushagak River, approximately 60 km upstream from the city of Dillingham and 4 km downstream from the village of Portage Creek (Figure 1). This area was chosen because it is the only place in the lower Nushagak River where the entire river is contained within one channel approximately 300 m wide. In addition, McBride and Mesiar (1981) concluded that the salmon reaching Portage Creek were at least 93% Nushagak, Mulchatna, and Nuyakuk River stocks.

Hydroacoustic Counting

Sonar equipment used on Nushagak River included four Bendix Corporation[1] side-scanning salmon counters. Design characteristics of Bendix counters were described in King and Tarbox (1989). Gaudet (1983) provided a detailed description of sonar equipment use and procedures for counting salmon. Two counters, inshore and offshore, were installed on the right and left (looking downstream) river bank. Inshore counters divided the counting range into 12 sectors; offshore counters divided the counting range into 16 sectors. All counters operated at 515 kHz with a pulse width of 100 µs. Counting range, pulse repetition rate, and sensitivity were adjustable.

Counting ranges of the equipment and placement and number of transducers were determined by the river bottom contour (Figures 2, 3). The river bottom at the right and left banks sloped downward toward the middle of the river at an even rate for 15 to 20 m, then sloped away at a steeper rate. Because of this bottom configuration, two transducers (inshore and offshore) were used on each side of the river. Offshore transducers, located where the bottom contour changed, counted outward. Inshore transducers were deployed within 10 m of shore in water of sufficient depth for fish passage and counted out to the offshore transducer.

Transducers were mounted on metal tripods and oriented to count the lower portion of the water column. Minard (1985) determined that over 88% of the fish occupied the lower two-fifths of the water column. With the aid of an oscilloscope, all transducers were aimed with the sonar beam tangent to the river bottom, maximizing ensonification of passing fish. Offshore transducers were aimed with remote-controlled pan and tilt rotators, whereas inshore transducers were aimed by manually adjusting the angle of the transducer mounts on the tripods. A weir was constructed from the shore to just beyond the inshore transducer on both river banks to prevent fish from passing behind the transducers or within the transducer dead range.

Pulse repetition rate was adjusted on each counter to maintain counting precision at ±90% using calibration procedures described by Minard and Frederickson (1983). Counters were calibrated by comparing counts recorded by a sonar counter to those recorded by a trained technician observing an oscilloscope pattern of the signal generated by that counter. Counts from the oscilloscope were hand tallied for either a 10-min period or 100 counts, whichever came first. At the end of the counting interval, the machine count was divided into the oscilloscope count to yield a percent agreement between the two. If the percent agreement was less than 90% or greater than 110%, the pulse repetition rate was adjusted until an acceptable percent agreement was achieved. Counters were calibrated throughout the day between 0600 and 2400 hours. Frequency of calibrations was somewhat dependent upon fish passage rates and the variability of fish swimming speeds; there was at least one calibration per hour during periods of peak fish passage.

Sonar count data were summarized by sector, counter location (inshore, offshore, left or right bank), hour, and day to evaluate spatial and temporal distributions of sonar counts.

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[1] Mention of a product name does not constitute endorsement.

Daily sonar counts were apportioned among salmon species using samples of the salmon passage that were collected with a 45.7-m (25-fathom) beach seine and 18.3-m (10-fathom) drift gillnets having mesh sizes of 20.6 cm (8.125 in), 13.0 cm (5.125 in), and 11.4 cm (4.5 in). A 15.2-cm (6.0-in) mesh gillnet was also fished experimentally to evaluate its performance and size selectivity. All gillnets were approximately 6 m deep. Neither twine size nor color were held constant among mesh sizes but were influenced by commercial availability. Beach seine sampling occurred just upstream of and gillnetting just downstream of the transducers so that catches would represent the relative abundance of fish passing through the corresponding sonar beams. Because of the possibility that species composition was different between inshore and offshore counting ranges, sampling was conducted inshore and offshore. Beach seines were only used inshore. Inshore sets with gillnets were started with one end on the bank; offshore sets were started with the near shore end of the net approximately the same distance from the shore as the offshore transducer. The 20.6-, 15.2-, and 13.0-cm mesh gillnets were fished from June 11 through July 19, 21, and 22, respectively. The 11.4 cm mesh gillnet was fished from July 15 through July 22. Each size of gillnet was fished for a minimum of two drifts inshore and two drifts offshore on each bank during each set of drifts. During the period of peak fish passage (June 19 – July 15), drift sessions were conducted three times daily: morning (0700–1100 hours), mid-day (1300–1700 hours), and evening (1800–2200 hours). Prior to June 19 and after July 15, drift sessions were conducted twice daily: mid-morning (0800–1000 hours) and early evening (1600–1800 hours). Drifts were not conducted at night because poor light conditions would make it impossible to maintain a drift within assigned strata. The maximum number of drifts conducted for each mesh size along each bank's inshore and offshore strata was six per day.

Data recorded for each gillnet drift included (1) date, (2) time the drift session began, (3) boat operator, (4) drift number sequentially ordered through the season, (5) mesh size, (6) right or left river bank, (7) inshore or offshore counting ranges, (8) net length in fathoms, (9) fishing time, (10) number and species of catch, (11) length of each fish caught, mid-eye to fork-of-tail to nearest millimeter, and (12) sex as determined from external characteristics. The following fishing times were determined and recorded using a stopwatch for each drift:

Time net started out *(SO)* - Min:Sec
Time net full out *(FO)* - Min:Sec
Time net started in *(SI)* - Min:Sec
Time net full in *(FI)* - Min:Sec

Gillnet escapement sampling data were entered into an R:BASE[2] database inseason.

When the fish passage rate on the right or left bank equaled or exceeded 1,000 fish/h, beach seines were used to sample inshore strata, whereas gillnets were used to sample offshore strata. For these days of high

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[2] Mention of product name does not constitute endorsement.

fish passage, at least three beach seine hauls per bank were conducted. The duration of a haul was not recorded because a unit of effort has not been defined for beach seining.

Species Composition Estimation

Daily estimates of fish by species were based on escapement samples and sonar count data. A program written in SAS[2] (1988) for use on the Yukon River (Fleischman et al. 1992) was modified to analyze Nushagak River data. Daily sonar counts were apportioned to species by bank and counting range. Four area strata were defined (1 = left inshore, 2 = left offshore, 3 = right inshore, 4 = right offshore). Catch per unit effort (CPUE) with an optional adjustment for selectivity was used to calculate species proportions. Catch per fathom hour was estimated for chinook (1), sockeye (2), coho (3), pink (4), and chum (5) salmon. The SAS program also estimated catch per fathom hour for whitefish (6) and "other" fish (7). However, catches of whitefish and "other" fish were minimal and not documented, so estimates for these two categories always computed to zero.

To estimate fishing effort, mean fishing time (MFT) was calculated for each drift:

$$MFT = SI - FO + \frac{(FO\text{-}SO) + (FI\text{-}SI)}{2} \quad .$$ (1)

The number of fathom hours (FH) was also calculated:

$$FH = \frac{f\ MFT}{60} \quad ,$$ (2)

where f was net length in fathoms (generally 10).

CPUE for each salmon species (group) was based on a subset of gillnet meshes fished. The combination of mesh sizes used to estimate the proportion of each species group was specified. Adjustments for selectivity were based on the probability, p, that a fish of species i and length category l was caught in mesh size m. Therefore, the adjusted catch (F) for the rth fish of species i, length category l, caught in the nth drift with mesh size m in area strata k on day j became

$$F_{ijklmnr} = \frac{1}{p_{ilm}} \quad .$$ (3)

If p is zero or undefined, F was set equal to zero. The probability of capture (p) was assumed to be equal to one for all length classes if no adjustment for selectivity was made. Without adjustment, $F_{ijklmnr}$ equals one.

CPUE was first estimated for each length category of a given species, day, and area strata combination. This was to acknowledge that the effort expended to capture a fish was dependent upon fish size. For example, a small fish of a given species might be vulnerable to capture (p defined) in only one mesh size, whereas a larger fish of the same species might have a non-zero probability of capture in two or more mesh sizes. The CPUE for each length category ($CPUE_{ijkl}$) was estimated:

$$CPUE_{ijkl} = \frac{\sum_{m=1}^{3} \sum_{n=1}^{6} \sum_{r=1}^{R} u_{im} \, F_{ijklmnr}}{\sum_{m=1}^{3} \sum_{n=1}^{6} u_{im} \, v_{ilm} \, FH_{jkmn}} \quad , \tag{4}$$

where:

u_{im} = 1 if species i from mesh m is used to estimate species composition, and

u_{im} = 0 otherwise;

v_{ilm} = 1 if the probability of capture (p) is defined for that species, length category, and net combination, and

v_{ilm} = 0 otherwise.

CPUE was then summed across all length categories for species i to estimate its daily $CPUE_{ijk}$ in area strata k:

$$CPUE_{ijk} = \sum_{l=1}^{L} CPUE_{ijkl} \quad . \tag{5}$$

CPUE were cumulated across days to create a time (t) and area stratified estimate of species composition. The duration of a time strata (report period) varied by range and bank and was specified as an input file. The desired sample size for each time-area strata was 100 salmon. Based on Thompson's (1987) "worst case" parameter value for a multinomial distribution, a sample size of 100 salmon would result in simultaneously estimating the proportion for each species within 10% of the true proportion 90% of the time. If less than 100 salmon were captured during a day in an area strata, catches from the same gear type from subsequent days were accumulated until 100 salmon were obtained to define a reporting period. The CPUE used to estimate the proportion of species i in report period t and area strata k was

$$CPUE_{itk} = \sum_{j \in t} CPUE_{ijk} \quad .$$ (6)

Estimates of the proportion (S_{itk}) of species i for report period t and area strata k became

$$S_{itk} = \frac{CPUE_{itk}}{\sum\limits_{i=1}^{7} CPUE_{itk}} \quad .$$ (7)

Variance ($V[S_{itk}]$) was modeled on the assumption that we were estimating the proportions in a cluster. As the database did not distinguish replicate drifts within a day, J daily CPUE in period t were considered replicates and the variance was calculated after Cochran (1977; page 66) as

$$V(S_{itk}) = \frac{1}{J} \sum_{j \in t} \left(\frac{CPUE_{ijk}}{\sum\limits_{i=1}^{7} \frac{CPUE_{ijk}}{7}} \right)^2 \frac{(S_{ijk} - S_{itk})^2}{(J-1)} \quad .$$ (8)

If beach seining occurred on a particular day and at least 100 salmon were caught, it would supersede any gillnet data for that area strata. Otherwise, catch data were pooled across several days of beach seining to obtain at least 100 salmon or were just ignored, in which case gillnet data were used. Species proportion estimates for the beach seine were based on the ratio of the number of species i caught (C_{itk}) to total catch for report period t and area strata k:

$$S_{itk} = \frac{C_{itk}}{\sum\limits_{i=1}^{7} C_{itk}} \quad .$$ (9)

Variance was estimated using equation (8) through substituting C_{ijk} for $CPUE_{ijk}$.

Salmon Escapement Estimation

Sonar counts for each area strata (right and left bank, inshore and offshore) were apportioned to species on a daily basis. Daily estimates for each salmon species and area strata (N_{ijk}) were based on estimates of species proportions (S_{itk}) from escapement sampling and daily sonar counts (n_{jk}):

$$N_{ijk} = S_{itk}n_{jk} \quad \text{where } j \in t \, . \tag{10}$$

Daily escapement by species was estimated by summing area strata estimates:

$$\hat{N}_{ij} = \sum_{k=1}^{4} N_{ijk} \, . \tag{11}$$

The daily estimate of variance became

$$V(N_{ij}) = \sum_{k=1}^{4} n_{jk}^2 V(S_{itk}) \quad \text{where } j \in t \, . \tag{12}$$

Cumulative numbers of salmon were estimated by summing daily estimates, and the variance was a sum of daily variances. This variance is conservative because some periods are a single day having a variance of zero.

Spatial Differences in Species Composition

The utilization of two transducers on each bank creating inshore and offshore counting ranges allowed for the estimation of species composition by range and bank. We assumed that species composition differed by range and bank. We tested the null hypothesis that species composition did not differ between counting ranges. If not rejected, data were pooled by bank to test the hypothesis that species composition did not differ between banks. Drift gillnet catches were stratified through time to account for the differences in migratory timing among salmon species. Length of time strata varied to incorporate overall sample sizes of 140 to 180 salmon in order to guarantee a power (β) greater than 0.8 for 2 or 3 df when $\alpha = 0.01$ and medium effective size (ES) of 0.3 based on Tables from Cohen (1988). The Bonferoni inequality (Mendenhall et al. 1986) was applied to set a significance criterion at 0.01 to allow for an overall significance criterion of 0.1 as multiple tests (maximum 10) were conducted. Chi-square tests for contingency tables were used to test these hypotheses. Catch data for each time strata were classified simultaneously by species and range (or bank) into a two-way contingency table.

Alternatives to Mean Fishing Time

As indicated in equation (1), MFT was calculated using three different time components: (1) time start net out until time net full out; (2) time net full out until time net start in; and (3) time net start in until time net full in. This required the time consuming collection and entry of four fishing times (SO, FO, SI, and FI). We wanted to develop an alternative to MFT that would increase the efficiency of escapement sampling and data entry, as well as reduce collection and entry errors. Three alternatives to MFT that would require the collection and entry of fewer fishing times are SI–FO (time net full out until time net start in), FI–SO (time net start out until time net full in), and FI–FO (time net full out until time net full

in). Each alternative to MFT requires only two fishing times to be recorded and entered into the database. Total escapement estimates calculated using MFT were compared to total escapement estimates calculated using the three alternatives to MFT. Escapement estimates for this comparison were calculated using beach seine data in combination with 15.2-cm mesh data for sockeye and chum salmon, 15.2- and 20.6-cm mesh data for chinook salmon, and 11.4-cm mesh data for pink salmon. No adjustment for gillnet size selectivity was included.

Gillnet Selectivity Estimates

Brannian et al. (*in press*) estimated gillnet selectivity curves for five species of salmon using a combination of Yukon River and Bristol Bay data and found that these curves could not be used for adjusting Nushagak River escapement sampling catches. They suggested that the failure of the selectivity curves may have been due to two factors: (1) differences between gillnets used to estimate selectivity curves and gillnets used for escapement sampling on Nushagak River, and (2) differences in the duration of escapement sampling drifts. They also recommended that selectivity curves should be produced using only Nushagak River drift gillnet data.

This was the second year that length data were collected with the intention of building Nushagak River gillnet selectivity curves based on Nushagak River salmon length data. We believe that 2 years of Nushagak River length data are not adequate for building reliable gillnet selectivity curves. Therefore, we decided to again estimate gillnet selectivity curves for chinook, sockeye, and chum salmon using Yukon River and Bristol Bay data. The method of McCombie and Fry (1960) was used to estimate probability of capture for chinook salmon (Figure 4) and chum salmon (Figure 5) in gillnets of 13.0, 15.2, and 20.6 cm mesh size. These selectivity curves were based on the length of chinook or chum salmon gilled or tangled in 10.2-cm, 12.7-cm, 14.0-cm, 16.5-cm, 19.1-cm, and 21.5-cm mesh gillnets from 1986–1990 in the Yukon River. This method assumed equal curve heights with modes proportional to mesh size. The method of Kawamura (1972) was used to estimate the probability of capture for sockeye salmon (Figure 6) in gillnets of 13.0, 15.2, and 20.6 cm mesh size. These curves were based on a length-girth relationship from sockeye salmon caught with 12.4-, 13.0-, 13.7-, and 14.3-cm mesh in 1984 from Egegik and Naknek-Kvichak commercial fishing districts of Bristol Bay (Bue 1986).

Mesh Size Selection and Adjustments for Selectivity

To estimate species composition, a selection of possible CPUE by species from the available mesh sizes needed to be made. Furthermore, we needed to decide whether to adjust those catches based on their probability of capture from our theoretical size-selectivity curves. The decision to adjust for chum and sockeye salmon probability of capture would be based upon the comparison of length frequency distributions of the seasons beach seine catch, the original gillnet catch data, and gillnet catch data adjusted for selectivity. We assumed that beach seines are not size selective for chum and sockeye salmon. Furthermore, this gear is used to describe the average age, sex, and length of the escapement.

Escapement estimates are effected to some degree by the combination of mesh sizes used in apportioning sonar counts. Escapement estimates for 1991 were calculated using catch and effort data from 13.0-cm and 20.6-cm mesh gillnets in combination with beach seine data (Brannian et al. *in press*). Sockeye and chum salmon escapements were estimated in 1991 using beach seine and 13.0-cm mesh data; chinook salmon were estimated using beach seine, 13.0-cm mesh, and 20.6-cm mesh data. To determine the effect that 15.2-cm mesh data have on the overall apportionment of 1992 sonar counts, the apportionment program was run using beach seine data and three different combinations of gillnet data: (1) 13.0-cm and 20.6-cm mesh; (2) 13.0-cm, 15.2-cm, and 20.6-cm mesh; and (3) 15.2-cm and 20.6-cm mesh. For each combination, 11.4-cm mesh data were used for calculating only pink salmon escapement. Escapement estimates calculated using the three mesh size combinations were compared.

Report Periods for Species Composition Estimates

We were also interested in how sensitive total escapement estimates for each species were to the length of the time strata or report periods. Brannian et al. (*in press*) reviewed three different schemes for determining report periods. The first scheme required a minimum sample size of 100 salmon per spatial and temporal strata. The second scheme relied on changes in species composition and had no minimum sample size. The third scheme defined no minimum sample size but used a 1-d report period. Brannian et al. (*in press*) determined that estimates of total escapement were not sensitive to the length of report periods and recommended using the 100-salmon minimum scheme because it reduced the subjectivity involved in determining report periods. We compared two additional report period schemes to the recommended method. The first included a time restriction in which a new report period was begun when (1) the sample size reached 100 salmon, or (2) a duration of 7 d had passed. This scheme was similar to the method used inseason. The second method was similar to the 100-salmon minimum scenario recommended by Brannian et al. (*in press*), except that it allowed changes in species composition. This scenario required a minimum sample size of 100 salmon per spatial and temporal strata except when (1) a species first appeared in escapement sampling catches, or (2) a substantial change in species composition occurred. Escapement estimates calculated using all three report-period scenarios were compared.

Age, Sex, and Size Sampling

Age, sex, and size (AWL) data were collected from chinook, sockeye, and chum salmon migrating past the sonar site. Only sockeye and chum salmon captured with beach seines were sampled for AWL data to avoid size-selectivity associated with gillnets. All chinook salmon captured were sampled to increase the number of AWL samples.

Age was determined by examining scales (Mosher 1968). Scales were collected from the left side of the fish approximately two rows above the lateral line in an area crossed by a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963). Because of the high rate of scale regeneration among chinook salmon, three scales were collected from each fish. Only one scale per fish was collected from sockeye and chum salmon. Scales were mounted on gummed cards and

impressions were made in cellulose acetate (Clutter and Whitesel 1956). We used European notation (Koo 1962) to record ages: numerals preceding the decimal refer to the number of freshwater annuli and numerals following the decimal refer to the number of marine annuli. Total age from time of egg deposition, or brood year, is the sum of these two numbers plus one to account for incubation time.

Sampling goals by species for the entire season were 1,200 sockeye, 600 chinook, and 400 chum salmon. The desired level of accuracy and precision for sockeye and chinook salmon age composition was 0.05. Based on Thompson's (1987) work, a sample size of 510 readable scales would simultaneously estimate the major age class within 5% of the true percentage 95% of the time. A sample size of 600 per strata was set for sockeye and chinook to account for regenerated and unageable scales. Two time strata were desired for sockeye salmon, therefore the goal for the season was set at 1,200. A sample size of 400 chum salmon scales ensured simultaneously estimating each major age class within 5% of the true percentage 90% of the time.

Salmon were measured from the middle of the eye to the fork of the tail and lengths were recorded to the nearest millimeter. Sex was determined from external characteristics.

RESULTS

Hydroacoustic Counting

Counting began on June 9 in right and left bank inshore and right bank offshore counting ranges, and on June 10 in the left bank offshore counting range. Counting ended on July 21 in right and left bank offshore counting ranges and on July 22 in right and left bank inshore counting ranges. A total of 1,089,234 counts were recorded (Table 1).

Gear Placement

Water level changes during project operation necessitated occasional repositioning of transducer tripods and adjustments of counting ranges (Table 2). The right bank inshore transducer counting range varied between 4.9 and 7.0 m, and the offshore transducer counting range varied between 18.9 and 19.2 m (Figure 2). Combined right bank counting range fluctuated between 23.8 and 26.2 m. The left bank inshore transducer ensonified between 7.0 and 8.8 m of river, and the left bank offshore transducer ensonified between 10.2 and 14.6 m (Figure 3). Combined left bank counting range varied between 17.6 and 23.1 m. Total ensonification for the right and left banks combined ranged from 38.5 to 48.1 m, or approximately 14% to 18% of the total river width.

Spatial Distribution of Sonar Counts

More counts occurred on the right bank (687,053) than on the left bank (402,181; Table 1). Most sonar counts for the right (90%) and left (91%) banks were recorded by the inshore sonar counters (Miller et al. 1993). Few counts were recorded at the end of the offshore counting ranges. The last four sectors of

the right bank offshore area accounted for 1.7% of the right bank offshore counts and only 0.2% of the right bank inshore and offshore combined counts. The last four sectors of the left bank offshore area accounted for 8.9% of the left bank offshore counts and only 0.8% of the left bank inshore and offshore combined counts.

Distribution of sonar counts by sector were similar for both right and left bank inshore counting ranges (Figures 7, 8). Several peaks in sonar counts occurred between June 26 and July 12 in the right and left bank inshore counting ranges. The largest peak in both strata occurred on July 12. The peak daily count by sector shifted from the offshore sectors to the inshore sectors as the season progressed, which corresponded with the increase in sockeye salmon passage.

Sonar count distribution by sector was more varied between the right and left bank offshore counting ranges (Figures 7, 8). A major peak in sonar counts occurred on June 26 in the right bank offshore counting range, and several smaller peaks occurred in the left bank offshore counting range between June 26 and July 12. Count distribution within the right bank offshore stratum indicated that most of the fish passage occurred in the inshore half of the counting range. Distribution of counts in the left bank offshore range, however, indicated that fish passage occurred throughout much of the counting range with a decrease in fish passage in the first and last few sectors.

Temporal Distribution of Sonar Counts

Information on patterns of hourly fish passage are of interest to determine optimal times for test fishing and equipment calibration. Any or all of a combination of variables such as tide, weather (winds, rainfall, etc.), and hours of daylight, as well as the time, date, and duration of commercial fishing periods might influence when migrating fish would pass the sonar site. Count distribution varied between days in all four location strata (Figure 9). No clear pattern of hourly fish passage was evident.

Escapement Sampling Catch and Effort

A total of 2,175 gillnet drifts were completed in 1992 (Miller et al. 1993). The 20.6-, 15.2-, and 13.0-cm mesh gillnets caught 484, 1,055, and 1,084 salmon, respectively. The 11.4-cm mesh gillnet caught 64 salmon. The total gillnet catch of 2,687 salmon was composed of 788 chinook, 887 sockeye, 999 chum, and 13 pink salmon. Most (1,009) salmon captured in gillnets were caught in the left inshore stratum, followed by 853 salmon in the right inshore, 441 in the left offshore, and 384 in the right offshore stratum. Beach seines were fished from June 26 through July 12 (Miller et al. 1993). A total of 3,855 salmon, mostly sockeye and chum, were caught in the beach seines. Only 33 chinook and 12 pink salmon were caught in beach seines.

The greatest number of sockeye salmon (3,052) were caught in beach seines followed by 13.0-cm mesh gillnets (407), 15.2-cm mesh (307), and 20.6-cm mesh (149) gillnets (Table 3). Most chum salmon were caught in beach seines (758), followed by 15.2 cm mesh gillnets (465), 13.0 cm mesh (406), and 20.6 cm mesh (117) gillnets (Table 4). Chinook salmon were captured predominantly in gillnets, with similar

numbers being caught between the 15.2-cm (282), 13.0-cm (270), and 20.6-cm (222) mesh gillnets (Table 5). Of the few pink salmon caught, most were captured in the beach seines and 11.4-cm mesh gillnet. Small numbers of pink, sockeye, chum, and chinook salmon were caught in the 11.4-cm mesh gillnet primarily because it was fished later in the season after the time of peak migration for most species and it was fished for only 8 d before the project was terminated.

MFT for all nets pooled was unimodally distributed though somewhat skewed to the right (Figure 10). MFT ranged from 1.7 to 6.9 min across all drifts with an average of 2.9 min (SE = 0.45). The average MFT was also 2.9 min for each mesh size with the 11.4-cm mesh having the smallest variance (SE = 0.28) and the 13.0-, 15.2-, and 20.6-cm meshes having equal variances (SE = 0.46).

Range Differences in Species Composition

Escapement sampling data were divided into eight periods (Table 6). There were significant differences ($\propto$ = 0.01) in species composition between inshore and offshore strata on the left bank for each period. These differences resulted from large catches of sockeye and chum salmon in the inshore strata and large catches of chinook salmon in the offshore strata. Significant differences in species composition were not found between the inshore and offshore ranges for the right bank during the first two periods. However, significant differences were found between right bank ranges during the last six periods. Differences between inshore and offshore ranges on the right bank were the result of higher than expected catches of sockeye salmon in the inshore range and lower than expected catches of chinook salmon in the offshore range. The lack of a significant difference in species composition during the first two periods was due to the low number of sockeye salmon present. Chum salmon migrating on the right bank demonstrated no consistent preference between the inshore and offshore range.

Because there were significance differences in species composition between inshore and offshore ranges on the left bank for all periods, no bank-to-bank comparisons were made.

Alternatives to Mean Fishing Time

Three alternatives to MFT were calculated this year. As expected, the average across all drifts was smallest for SI–FO (2.4 min) and largest for FI–SO (3.4 min; Figure 11). The least variable with the smallest CV (0.08) was SI–FO.

Small differences (<1.0%) were found among escapement estimates calculated using MFT and escapement estimates calculated using the three alternatives to MFT (SI–FO, FI–SO, FI–FO; Table 7). The highest percentage difference occurred in estimates calculated with FI–SO (0.7%), followed by SI–FO (0.5%), and FI–FO (0.3%). The small percentage differences in the estimates can be attributed to the short duration of the drifts as well as the unimodal and symmetrical distribution and the small variance of both MFT (Figure 10) and the individual components of MFT (Figure 12).

There was close agreement between the length frequency distribution (LFD) of sockeye salmon caught in beach seines and the 13.0-cm mesh gillnet (Figure 13). The 13.0-cm mesh gillnet appeared to catch slightly larger sockeye salmon than did the beach seine. A secondary mode in the beach seine LFD around 410 mm was absent in the 13.0-cm mesh LFD, indicating that the 13.0-cm mesh gillnet failed to capture these smaller sockeye salmon. When adjusted for selectivity, the 13.0-cm mesh gillnet LFD shifted right, away from the beach seine LFD. The 15.2-cm mesh gillnet LFD was less similar to the beach seine LFD in that the gillnet caught more large sockeye salmon (Figure 14). Adjusting the 15.2-cm mesh truncated the data and ignored all fish <450 mm, a size which composed a substantial portion of the beach seine catch. The 20.6-cm mesh gillnet LFD was similar to that of the beach seine, and no adjustment for selectivity was necessary (Figure 15).

LFD's of chum salmon caught in beach seines and of chum salmon caught in 13.0- and 15.2-cm mesh gillnets also showed close agreement (Figures 16–17). Adjusting the 13.0-cm mesh for size-selectivity shifted the LFD substantially to the right, away from the beach seine LFD (Figure 16). The 15.2-cm mesh gillnet caught slightly larger chum salmon than the beach seine. When the 15.2-cm mesh LFD was adjusted for size-selectivity, it overcompensated for small (<530 mm) and large (>650 mm) chum salmon (Figure 17). The 20.6-cm mesh gillnet LFD indicated that this mesh size caught more large chum salmon than did the beach seine (Figure 18). Neither the original LFD of chum salmon caught in 20.6-cm mesh gillnet, nor the adjusted LFD, showed any agreement with the beach seine LFD.

Too few chinook salmon were caught in beach seines to estimate a population LFD. The number of drifts conducted was similar between the three mesh sizes, so total numbers of chinook salmon caught can be loosely compared (Figure 19). As expected, the 13.0- and 15.2-cm mesh gillnets both selected for small chinook salmon (550 to 670 mm), but also caught a sizable number of large chinook salmon (>730 mm). The 20.6-cm mesh selected for sizes greater than 710 mm. Adjusting the 13.0-cm mesh catch for selectivity truncated the data at 790 mm and ignored larger chinook salmon (Figure 20). Selectivity adjustment of the 15.2-cm mesh catch overcompensated for large chinook salmon (>790 mm; Figure 21). Adjusting for selectivity did not greatly change the LFD for chinook salmon caught in the 20.6-cm mesh gillnet (Figure 22).

Varying the mesh size combinations used in the apportionment process did not greatly effect escapement estimates for chinook, chum, and sockeye salmon (Table 8); the largest difference occurred for sockeye and chum salmon when only 13.0-cm mesh data was used versus only 15.2-cm mesh data. The chum salmon estimate increased 10% from the 13.0-cm mesh apportionment to the 15.2-cm mesh apportionment, whereas chinook and sockeye salmon estimates decreased by 5% and 4%. As expected, the 15.2-cm mesh gave more weight to chum salmon. There was < 6% difference between escapement estimates calculated using both 13.0- and 15.2-cm mesh data for sockeye and chum salmon and the escapement estimates calculated using data from only one of these two mesh sizes.

Report Periods for Species Composition Estimates

The difference among the three report period schemes was the number of periods and their boundaries (Table 9). When the 100-fish minimum and 7-d maximum sample criterion was used the CPUE data were grouped into 13 report periods for the left inshore, 5 for the left offshore, 14 for the right inshore, and 4 for the right offshore stratum. Using the 100-fish minimum sample criterion resulted in 13 report periods for the left inshore, 3 for the left offshore, 13 for the right inshore, and 2 for the right offshore stratum. The 100-fish minimum or change in species composition criterion produced 14 report periods for the left inshore, 15 report periods for the right inshore, and 4 report periods for each of the offshore strata. Report periods for this scheme were determined by (1) the first appearance of a species or (2) a species composition change in the escapement samples. Chinook and chum salmon were present in escapement sample catches from the start of the program, sockeye salmon did not appear until June 19, and pink salmon did not appear until July 11. Because a new species appeared in the catch, new report periods were established in each spatial strata on these dates.

The only other change in species composition that affected the 100-fish minimum sample size occurred between July 2 and July 5. According to the 100-fish minimum criterion, catches on July 2–5 should have been combined into a single period in each inshore strata. However, there was a substantial change in species proportions from July 2–3 to July 4–5. In both strata between July 2 and July 5, the proportion of sockeye salmon in escapement sample catches increased by at least 0.40, while the proportion of chum salmon decreased by at least 0.40 (Table 10). There was also a substantial increase in sonar counts beginning July 4. Counts doubled from 26,718 on July 2–3 to 54,160 on July 4–5 (Table 2). This trend remained evident for several days, indicating that a large number of sockeye salmon began migrating past the sonar site on July 4. For this reason, data from July 2–3 and data from July 4–5 were grouped into separate report periods for each inshore strata.

Estimates of total escapement were not sensitive to our choice of report periods (Table 11). Differences in escapement estimates among all species and reporting schemes were less than 3%.

Estimates of Escapement

Our final estimate of Nushagak River escapement in 1992 was 1,089,234 salmon. This included 695,108 sockeye, 82,848 chinook, and 302,678 chum salmon (Table 12). We also counted 8,600 pink salmon before the project terminated on July 22. These estimates were based on our decision to (1) maintain the right and left bank, inshore and offshore counting ranges, (2) use MFT in CPUE calculations, (3) not adjust gillnet catches for size selectivity, (4) use 13.0-cm mesh gillnet catch of sockeye and chum salmon, (5) use 13.0-cm and 20.6-cm mesh catches of chinook salmon, (6) use 11.4-cm mesh catches of pink salmon, and (7) define new report periods for escapement sampling when the 100-fish sample size was satisfied or when there was a substantial change in species composition of the escapement sample catches.

Sockeye Salmon

According to escapement sampling data, sockeye salmon did not begin migrating past the sonar site until June 19 (Table 12). The 1992 escapement estimate of 695,108 sockeye salmon was 126% of the 550,000 escapement goal midpoint, but within the escapement goal range of 340,000 to 760,000.

Escapement timing of sockeye salmon for 1992 appeared similar to previous years (Table 13; Figure 23). Sockeye salmon were estimated at the sonar site from June 19 through the end of the project on July 22. Peak sockeye salmon passage occurred on July 12 with an estimate of 173,110, 25% of the entire 1992 sockeye salmon escapement estimate.

Age and sex was determined for 1,515 sockeye salmon, 1,502 of which were also measured for length (Table 14). The most prominent age class was age-1.3 (1987 brood year) at 32%, followed by age-0.3 (1988 brood year) at 20%, and age-0.4 (1987 brood year) and -1.4 (1986 brood year) both at 10%. The percentage of males and females were 48% and 52%. Mean length by age ranged from 414 to 580 mm (Table 14).

Chinook Salmon

Chinook salmon were counted at the sonar site immediately following installation of the sonar equipment (Table 12). The 1992 escapement estimate of 82,848 chinook salmon was 110% of the 75,000 escapement goal midpoint, within the escapement goal range of 50,000 to 100,000 chinook salmon.

Escapement timing of chinook salmon for 1992 appeared similar to the previous 9 years (Table 15; Figure 24). Chinook salmon were estimated at the sonar site from June 9 through the end of the project on July 22. Peak chinook salmon passage occurred between June 26 and July 1, major peaks occurred on July 26 and June 30. Daily passage estimates for these two days were 8,043 and 7,036 chinook salmon.

Age and sex were determined for 593 chinook salmon, 587 of which were also sampled for length (Table 16). Three major age classes were present: age-1.3 (37%; 1987 brood year); -1.4 (32%; 1986 brood year); and -1.2 (27%; 1988 brood year). The chinook salmon escapement was estimated to be 50% males and 50% females. Mean length by age ranged from 390 to 963 mm (Table 16).

Chum Salmon

As with chinook salmon, chum salmon were counted migrating past the sonar site the same day the sonar equipment was installed, June 9 (Table 12). The 1992 escapement estimate of 302,678 chum salmon was 86% of the 350,000 escapement goal midpoint.

Escapement timing appeared to be slightly earlier in 1992 compared to the previous 12 years (Table 17; Figure 25). Peak chum salmon passage occurred on June 26 with an estimate of 70,147, 23% of the entire

1992 chum salmon escapement. Chum salmon were counted past the sonar site from June 9 through the end of the project on July 22.

Age and sex were determined for 646 chum salmon, 641 of which were measured for length (Table 18). Age-0.4 (55%; 1987 brood year) and -0.3 (45%; 1988 brood year) chum salmon predominated. The percentage of males and females were 49% and 51%. Mean length by age ranged from 560 to 620 mm (Table 18).

DISCUSSION

Information on inriver fish distribution is important in considering the reliability of estimates generated by sonar counts. If appreciable numbers of fish were migrating upstream in areas of the river not ensonified by the sonar, then the estimates would be low. We found that on both river banks, most counts occurred in the inshore strata. In addition, most counts in the offshore strata (16 sectors) were observed within the first 12 sectors. Few counts were observed at the end of the offshore ranges. Therefore, we conclude that the majority of fish passage occurred within the counting ranges of the sonar equipment.

Inshore and offshore stratification was maintained for calculation of the 1992 final escapement estimates because significant differences in species composition occurred between ranges. We looked at range differences in species composition in an attempt to reduce the number of ranges and thus reduce the amount of escapement sampling effort expended. We had also hoped that by combining ranges in the future, we would increase drift durations. In the past, drift durations have been cut short because it was difficult to maintain gillnet drifts within the corridors defined by the individual ranges. Unfortunately, inshore and offshore stratification was necessary and should be continued in 1993.

We decided to use MFT for calculating the 1992 escapement estimates because it was available. However, we recommend that in 1993 MFT be replaced with SI–FO. Results indicated that MFT could be replaced with any of the three alternative times, depending upon which time was more practical to collect and enter into the database. According to field personnel, SI–FO would be the easiest time to record while test fishing. In addition, previous project leaders (B.G. Bue, Alaska Department of Fish and Game, Anchorage, personal communication) have questioned whether the gillnet is effectively fishing once the net begins to be retrieved from the water (FI–SI). At that point, the integrity of the drift deteriorates, and the net often becomes parallel, not perpendicular, to shore. Therefore, it may be more appropriate to drop this component. For these reasons SI–FO appeared to be the best alternative to MFT. Two very important assumptions must be made when MFT is replaced with one of the three alternative times: (1) fish catchability during net deployment and net retrieval remains consistent between drifts, and (2) net deployment and retrieval times remain consistent between drifts. We emphasize that SI–FO should not be used as an alternative to MFT if either of these two assumptions are not met.

Adjusting escapement sampling catches for size selectivity did not appear to be beneficial for any of the mesh sizes or species. LFDs of sockeye salmon caught in 13.0-, 15.2-, and 20.6-cm mesh gillnets were all similar to the beach seine LFD. Adjusting for size selectivity tended to shift gillnet LFDs further away from the beach seine LFD resulting in adjusted gillnet catches that were not representative of the beach

seine catch. The differences among gillnet LFDs and the beach seine LFD of chum salmon were greater than that of sockeye salmon, but as with sockeye salmon, adjusting for size selectivity resulted in a shift of the gillnet LFDs away from the beach seine LFD. The adjusted chum salmon gillnet LFDs were not representative of the beach seine LFD. Although it was not possible to compare gillnet catches of chinook salmon with representative beach seine catches, we question the appropriateness of adjusting gillnet catches for size selectivity using current selectivity curves. The 13.0- and 15.2-cm mesh gillnets both caught more large size chinook salmon than expected.

We feel that the failings of our selectivity curves are due to two factors. First, they were estimated from stocks of salmon caught in gillnets with different mesh sizes, twine types, and colors. Second, these other gillnets were fished very differently than ours. Gillnets are drifted in the Yukon River for longer than 10 min. Bue (1986) contracted commercial fishermen to drift variable mesh gillnets for one hour. Those drifts were considerably longer than our average 2.9-min drifts. Our drifts may have been too short to allow struggling fish any time to escape and may explain our perceived lack of size selectivity. We recommend fishing 13.0-, 15.2-, and 20.6-cm mesh gillnets again in 1993 and building Nushagak River selectivity curves based on salmon caught in these nets. The 11.4-cm mesh gillnet will not be fished in 1993 because pink salmon return only in even years.

In calculating the final escapement estimates, we used only 13.0-cm mesh gillnet data for apportionment of sockeye and chum salmon and 13.0- and 20.6-cm mesh data for apportionment of chinook salmon. The 13.0-cm mesh gillnet was not size selective for any of the three species, but the 20.6-cm mesh gillnet tended to select for large sockeye and chum salmon. Therefore, we decided to use 13.0-cm mesh data for sockeye and chum salmon and use 13.0- and 20.6-cm mesh data for chinook salmon. Data from the 15.2-cm mesh gillnet were excluded for all species because this mesh size was an experimental net. If time was limited inseason and not all assigned drifts could be conducted during a given sampling session, the 15.2-cm mesh gillnet had the lowest priority and was dropped from that session. Thus this mesh size was not fished as uniformly as the other two.

We also decided to calculate the 1992 escapement estimate using the report period criteria which requires either a 100-fish minimum sample size or a change in species composition of escapement sampling catches. Although Brannian et al. (*in press*) suggested using only the 100-fish minimum criteria, we found that it was difficult to ignore an obvious change in species composition. In addition, we found that the total estimates of escapement appeared fairly insensitive to our choice of report period scenarios.

LITERATURE CITED

Brannian, L.K., S.J. Fleischman, J.D. Miller, and B.A. Cross. *In press*. Evaluation of species composition escapement estimates of Pacific salmon into the Nushagak River, 1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Draft Technical Fisheries Report, Anchorage.

Bue, B.G. 1986. Effects of gill net selectivity on sockeye salmon in the Egegik and Naknek-Kvichak Districts, Bristol Bay, Alaska. Masters Thesis, University of Alaska, Fairbanks.

LITERATURE CITED (Continued)

Bue, B.G. 1988a. Sonar enumeration of Pacific salmon escapement to the Nushagak River, 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A88-5, Anchorage.

Bue, B.G. 1988b. Sonar enumeration of Pacific salmon escapement to the Nushagak River, 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2D88-10, Anchorage.

Clutter, R., and L. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. International Pacific Salmon Fisheries Commission Bulletin 9.

Cochran, W.G. 1977. Sampling techniques, 3rd edition. John Wiley & Sons, New York.

Cohen, J. 1988. Statistical power analysis for the behavioral sciences, second edition. Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey.

Fleischman, S., D.C. Mesiar, and P. Skvorc. 1992. Yukon River sonar estimate appendices 1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A92-09, Anchorage.

Gaudet, D.M. 1983. 1982 Bendix adult counter manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau.

INPFC (International North Pacific Fisheries Commission). 1963. Annual report 1961, Vancouver, British Columbia.

Kawamura, G. 1972. Gill-net mesh selectivity curve developed from length-girth relationship. Bulletin of the Japanese Society of Scientific Fisheries 38(10): 1119–1127.

King, B.E., and K.E. Tarbox. 1989. Upper Cook Inlet salmon escapement studies, 1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau. Technical Fisheries Report 89-19, Juneau.

Koo, T.S.Y. 1962. Age designation in salmon. Pages 37–48 in T.S.Y. Koo, editor. Studies of Alaska red salmon. University of Washington Publications in Fisheries, New Series, Volume I, Seattle.

McBride, D.N. 1981. Nushagak River sonar enumeration studies, 1979. Appendix A in Nushagak sonar enumeration project, 1980. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report 83, Anchorage.

McBride, D., and D. Mesiar. 1981. Nushagak sonar enumeration project, 1980. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report 83, Anchorage.

McBride, D., and D. Mesiar. 1982. Nushagak sonar enumeration project, 1981. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report 88, Anchorage.

LITERATURE CITED (Continued)

McCombie, A.M., and F.E.J. Fry. 1960. Selectivity of gill nets for lake whitefish, *Coregonus clupeaformis*. Transactions of the American Fisheries Society 89(2):176–184.

Mendenhall, W., R.L. Scheaffer, D.D. Wackerly. 1986. Mathematical statistics with applications. Third Edition. Duxbury Press, Boston.

Miller, J.D., L.K. Brannian, and B.A. Cross. 1993. Appendices to: Sonar enumeration of Pacific salmon into the Nushagak River and evaluation of species composition estimation, 1992. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A93-19, Anchorage.

Minard, R.E. 1983. Nushagak sonar enumeration project, 1982. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report 92, Anchorage.

Minard, R.E. 1985. Nushagak sonar salmon enumeration project, 1984. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report 85-3, Anchorage.

Minard, R.E., and M. Frederickson. 1983. Nushagak River sonar salmon enumeration project, 1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report 97, Anchorage.

Morstad, S.P., and R.E. Minard. 1986. Nushagak sonar salmon enumeration project, 1985. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report 86-3, Anchorage.

Morstad, S.P., and R.E. Minard. 1988. Nushagak sonar salmon enumeration project, 1986. Alaska Department of Fish and game, Division of Commercial Fisheries, Bristol Bay Data Report 87-3, Anchorage.

Mosher, K. 1968. Photographic atlas of sockeye salmon scales. Fishery Bulletin 67:243–280.

Thompson, S.K. 1987. Sample size for estimating multinomial proportions. The American Statistician, 41:42–46.

SAS Institute Inc. 1988. SAS language guide for personal computers, Release 6.03 Edition. Cary, North Carolina.

Woolington, J.D., and B.G. Bue. 1989. Sonar enumeration of Pacific salmon escapement into the Nushagak River, 1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2D89-17, Anchorage.

Woolington, J.D., and J.D. Miller. 1992. Sonar enumeration of Pacific salmon escapement into the Nushagak River, 1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A92-30, Anchorage.

Tables and Figures

Table 1. Inshore and offshore sonar counts
by bank and day for the Nushagak
River sonar project, 1992.

Date	Left Bank		Right Bank		Total
	Inshore	Offshore	Inshore	Offshore	
6/09	99		186	92	377
6/10	94	0	256	30	380
6/11	84	22	119	63	288
6/12	83	42	198	62	385
6/13	397	379	1,513	1,655	3,944
6/14	772	348	1,176	561	2,857
6/15	332	228	611	537	1,708
6/16	724	174	1,847	740	3,485
6/17	1,975	205	5,033	1,725	8,938
6/18	2,264	300	5,845	2,577	10,986
6/19	1,737	245	1,005	792	3,779
6/20	1,672	181	1,305	1,488	4,646
6/21	4,508	200	1,048	2,069	7,825
6/22	3,364	141	1,415	1,643	6,563
6/23	2,140	141	743	996	4,020
6/24	2,079	192	833	1,152	4,256
6/25	2,181	146	1,819	1,202	5,348
6/26	33,446	2,357	46,603	16,620	99,026
6/27	21,662	2,308	36,367	10,463	70,800
6/28	10,713	931	37,531	4,456	53,631
6/29	9,788	422	20,194	2,413	32,817
6/30	14,727	814	24,626	1,354	41,521
7/01	10,336	1,493	16,631	989	29,449
7/02	4,096	856	11,622	595	17,169
7/03	3,031	780	5,259	479	9,549
7/04	5,822	1,001	18,104	782	25,709
7/05	5,563	1,385	21,058	445	28,451
7/06	25,730	3,308	43,287	1,461	73,786
7/07	36,430	1,584	47,138	1,467	86,619
7/08	13,765	1,498	26,871	1,335	43,469
7/09	4,089	1,080	11,282	350	16,801
7/10	2,996	892	8,876	419	13,183
7/11	43,658	2,915	64,157	1,493	112,223
7/12	77,183	3,438	108,637	2,596	191,854
7/13	7,308	1,155	18,913	977	28,353
7/14	3,530	817	8,900	707	13,954
7/15	1,712	665	4,831	483	7,691
7/16	1,741	726	3,308	316	6,091
7/17	1,852	473	2,498	232	5,055
7/18	780	492	1,293	262	2,827
7/19	709	340	1,268	173	2,490
7/20	730	180	1,383	110	2,403
7/21	1,010	57	2,010	166	3,243
7/22	358		927		1,285
Total	367,270	34,911	618,526	68,527	1,089,234

Table 2. Counting ranges for sonar counters on right and left banks, Nushagak River sonar project, 1992.

	Right Bank				Left Bank			
	Inshore		Offshore		Inshore		Offshore	
Date	Distance[a](m)	Date	Distance (m)	Date	Distance (m)	Date	Distance (m)
6/09	6.1	6/09 - 6/28	19.2	6/09	7.0	6/09 - 6/11	14.6
6/10 - 6/18	5.5	6/29 - 7/22	18.9	6/10 - 6/13	8.5	6/12 - 6/22	12.5
6/19 - 6/21	5.2			6/14 - 6/22	8.8	6/23 - 6/24	10.4
6/22 - 6/23	5.5			6/23	8.2	6/25 - 6/27	10.2
6/24	5.2			6/24	7.7	6/28	10.7
6/25 - 7/04	5.5			6/25	7.4	6/29 - 6/30	10.4
7/05 - 7/06	5.2			6/26 - 7/04	8.3	7/01 - 7/22	11.0
7/07	5.3			7/05 - 7/22	8.6		
7/08 - 7/09	5.5						
7/10	4.9						
7/11 - 7/22	5.5						

[a] Total distance from transducer that sonar beam was set to count fish.

Table 3. Length frequency for sockeye salmon caught in beach seines and 13.0-, 15.2-, and 20.6-cm mesh gillnets, Nushagak River sonar project, 1992.

Length (mm)	Beach Seine Numbers	Percent	13.0 cm Numbers	Percent	15.2 cm Numbers	Percent	20.6 cm Numbers	Percent
310	0	0	0	0	0	0	0	0
330	0	0	0	0	0	0	0	0
350	2	0	0	0	1	0	0	0
370	3	0	0	0	0	0	0	0
390	26	1	1	0	0	0	0	0
410	66	4	6	2	6	2	4	3
430	111	6	8	2	8	3	6	4
450	52	3	6	2	6	2	5	4
470	80	4	19	5	5	2	2	1
490	95	5	27	7	9	3	9	6
510	172	10	54	14	23	8	9	6
530	260	14	54	14	32	11	21	15
550	266	15	65	16	56	18	24	17
570	281	16	58	15	44	15	13	9
590	208	12	49	12	51	17	20	14
610	104	6	32	8	32	11	14	10
630	62	3	10	3	15	5	10	7
650	12	1	8	2	12	4	1	1
670	0	0	0	0	2	1	2	1
690	0	0	1	0	1	0	1	1
710	0	0	1	0	0	0	0	0
730	0	0	0	0	0	0	1	1
750	0	0	1	0	0	0	0	0
	1,800	100	400	100	303	100	142	100
No Length	1,252		7		4		7	
Total	3,052		407		307		149	

Table 4. Length frequency for chum salmon caught in beach seines and 13.0-, 15.2-, and 20.6-cm mesh gillnets, Nushagak River sonar project, 1992.

Length (mm)	Beach Seine		13.0 cm		15.2 cm		20.6 cm	
	Numbers	Percent	Numbers	Percent	Numbers	Percent	Numbers	Percent
400	0	0	0	0	0		0	0
420	0	0	0	0	0	0	0	0
440	1	0	2	1	0	0	0	0
460	0	0	0	0	0	0	0	0
480	0	0	3	1	1	0	0	0
500	11	2	6	2	1	0	0	0
520	33	5	22	6	7	2	0	2
540	109	16	38	10	17	4	2	4
560	135	19	63	16	63	14	8	14
580	157	23	85	21	105	23	8	23
600	114	16	77	19	105	23	10	23
620	79	11	51	13	87	19	22	19
640	39	6	22	6	44	10	26	10
660	14	2	23	6	26	6	19	6
680	1	0	6	2	5	1	11	1
700	0	0	2	1	2	0	4	0
720	1	0	0	0	0	0	3	0
740	0	0	0	0	0	0	1	0
760	0	0	0	0	0	0	1	0
780	0	0	0	0	0	0	0	0
	694	100	400	100	463	100	115	100
No Length	64		6		2		2	
Total	758		406		465		117	

Table 5. Length frequency for chinook salmon caught in beach seines and 13.0-, 15.2-, and 20.6-cm mesh gillnets, Nushagak River sonar project, 1992.

Length (mm)	Beach Seine		13.0 cm		15.2 cm		20.6 cm	
	Numbers	Percent	Numbers	Percent	Numbers	Percent	Numbers	Percent
310	0	0	0	0	0	0	0	0
350	1	3	0	0	0	0	0	0
390	5	14	1	0	0	0	0	0
430	2	5	3	1	0	0	0	0
470	5	14	4	2	0	0	1	0
510	1	3	11	4	2	1	0	0
550	2	5	22	9	28	10	3	1
590	11	30	45	18	49	18	5	2
630	1	3	36	14	36	13	8	4
670	1	3	12	5	13	5	4	2
710	3	8	12	5	20	7	15	7
750	3	8	12	5	15	6	23	11
790	0	0	18	7	22	8	18	8
830	1	3	13	5	24	9	38	18
870	0	0	23	9	18	7	18	8
910	1	3	24	9	19	7	39	18
950	0	0	13	5	17	6	28	13
990	0	0	6	2	6	2	11	5
1030	0	0	0	0	0	0	3	1
1070	0	0	0	0	0	0	0	0
1110	0	0	0	0	0	0	0	0
1150	0	0	0	0	0	0	1	0
	37	100	255	100	269	100	215	100
No Length	0		15		13		7	
Total	37	100	270	100	282	100	222	100

Table 6. Chi-square test results comparing gillnet catches among inshore and offshore strata by period and river bank, Nushagak River sonar project, 1992.

Period	River Bank	Chi-square	df	Approximate Probability of Larger Value
6/11-6/23	Right	8.303	2	0.016
	Left	31.589	2	0.000[a]
6/24-6/27	Right	3.297	2	0.192
	Left	17.647	2	0.000[a]
6/28-6/30	Right	10.437	2	0.000[a]
	Left	19.498	2	0.000[a]
7/01-7/02	Right	22.104	2	0.000[a]
	Left	46.472	2	0.000[a]
7/03-7/04	Right	13.692	2	0.001[a]
	Left	42.848	2	0.000[a]
7/05-7/09	Right	27.342	2	0.000[a]
	Left	93.576	2	0.000[a]
7/10-7/14	Right	20.160	2	0.000[a]
	Left	41.006	2	0.000[a]
7/15-7/22	Right	15.074	3	0.002[a]
	Left	38.372	3	0.000[a]

[a] Significant at $\alpha=0.01$.

Table 7. Comparison of species apportionment estimates using alternatives to mean fishing time (MFT), Nushagak River sonar project, 1992.

Alternative Drift Time Used In Analysis[a]	Species	Original Estimate (Using MFT)	New Estimate	Difference	Percentage Difference
SI-FO	Chinook	82,848	83,228	380	0.46
	Sockeye	695,108	694,925	-183	-0.03
	Chum	302,678	302,493	-185	-0.06
	Pink	8,600	8,589	-11	-0.13
FI-SO	Chinook	82,848	82,271	-577	-0.70
	Sockeye	695,108	695,378	270	0.04
	Chum	302,678	302,967	289	0.10
	Pink	8,600	8,618	18	0.21
FI-FO	Chinook	82,848	82,790	-58	-0.07
	Sockeye	695,108	695,178	70	0.01
	Chum	302,678	302,695	17	0.01
	Pink	8,600	8,571	-29	-0.34

[a] SI-FO = Time net full out until time net start in,
FI-SO = Time net start out until time net full in,
FI-FO = Time net full out until time net full in.

Table 8. Comparison of species apportionment estimates using different combinations of mesh sizes, Nushagak River sonar project, 1992.

Mesh Sizes (cm) Included In Apportionment[a]			Number of Salmon				
Chinook	Sockeye	Chum	Chinook	Sockeye	Chum	Pink	Total
13.0,20.6	13.0	13.0	82,848	695,108	302,678	8,600	1,089,234
13.0,15.2,20.6	13.0,15.2	13.0,15.2	83,075	681,695	315,170	9,294	1,089,234
		% Difference	0.3	1.9	4.1	8.1	
13.0,20.6	13.0	13.0	82,848	695,108	302,678	8,600	1,089,234
15.2,20.6	15.2	15.2	78,435	667,798	332,273	10,728	1,089,234
		% Difference	5.3	3.9	9.8	24.7	
13.0,15.2,20.6	13.0,15.2	13.0,15.2	83,075	681,695	315,170	9,294	1,089,234
15.2,20.6	15.2	15.2	78,435	667,798	332,273	10,728	1,089,234
		% Difference	5.6	2.0	5.4	15.4	

[a] Pink salmon estimates were calculated using only 11.4-cm mesh data.

Table 9. Report periods for pooling escapement sampling data for the estimation of species composition, Nushagak River sonar project, 1992.

| | Report Period Criteria And Counting Range[a] | | | | | | | | | | | |
| | Sample Size >100 Or 7 d | | | | Sample Size >100 | | | | Sample Size >100 Or Change In Species Composition | | | |
Date	1	2	3	4	1	2	3	4	1	2	3	4
6/09	1	1	1	1	1	1	1	1	1	1	1	1
6/10	1	1	1	1	1	1	1	1	1	1	1	1
6/11	1	1	1	1	1	1	1	1	1	1	1	1
6/12	1	1	1	1	1	1	1	1	1	1	1	1
6/13	1	1	1	1	1	1	1	1	1	1	1	1
6/14	1	1	1	1	1	1	1	1	1	1	1	1
6/15	1	1	1	1	1	1	1	1	1	1	1	1
6/16	1	1	1	1	1	1	1	1	1	1	1	1
6/17	1	1	1	1	1	1	1	1	1	1	1	1
6/18	1	1	1	1	1	1	1	1	1	1	1	1
6/19	1	1	1	1	1	1	1	1	2	2	2	2
6/20	2	2	2	1	1	1	1	1	2	2	2	2
6/21	2	2	2	1	1	1	1	1	2	2	2	2
6/22	2	2	2	1	1	1	1	1	2	2	2	2
6/23	2	2	2	1	2	1	1	1	2	2	2	2
6/24	2	2	2	1	2	1	1	1	2	2	2	2
6/25	2	2	2	1	2	1	1	1	2	2	2	2
6/26	3	2	3	1	3	1	2	1	3	2	3	2
6/27	4	2	4	1	4	1	3	1	4	2	4	2
6/28	5	2	5	2	5	1	4	1	5	2	5	2
6/29	5	3	6	2	5	1	5	1	5	2	6	2
6/30	5	3	6	2	5	2	5	1	5	2	6	2
7/01	5	3	6	2	5	2	5	1	5	2	6	2
7/02	6	3	7	2	6	2	6	1	6	3	7	2
7/03	6	3	7	3	6	2	6	2	6	3	7	3
7/04	6	3	7	3	6	2	6	2	7	3	8	3
7/05	6	3	7	3	6	2	6	2	7	3	8	3
7/06	7	4	8	3	7	2	7	2	8	3	9	3
7/07	8	4	9	3	8	2	8	2	9	3	10	3
7/08	9	4	10	3	9	2	9	2	10	3	11	3
7/09	10	4	11	3	10	2	10	2	11	3	12	3
7/10	10	4	11	3	10	2	10	2	11	3	12	3
7/11	11	4	12	4	11	2	11	2	12	4	13	4
7/12	12	4	13	4	12	2	12	2	13	4	14	4
7/13	13	5	14	4	13	3	13	2	14	4	15	4
7/14	13	5	14	4	13	3	13	2	14	4	15	4
7/15	13	5	14	4	13	3	13	2	14	4	15	4
7/16	13	5	14	4	13	3	13	2	14	4	15	4
7/17	13	5	14	4	13	3	13	2	14	4	15	4
7/18	13	5	14	4	13	3	13	2	14	4	15	4
7/19	13	5	14	4	13	3	13	2	14	4	15	4
7/20	13	5	14	4	13	3	13	2	14	4	15	4
7/21	13	5	14	4	13	3	13	2	14	4	15	4
7/22	13	5	14	4	13	3	13	2	14	4	15	4

[a] Counting Range: 1=left inshore, 2=left offshore, 3=right inshore, 4=right inshore.

Table 10. Escapement sampling catch proportions by counting range, report period, date, and species, Nushagak River sonar project, 1992.

Counting[a] Range	Report Period	Date[b]	Catch[c]	Proportion of Catch					
				Chinook	Sockeye	Chum	Pink	Coho	Total
1	1	6/13	15	0.59	0.00	0.41	0.00	0.00	1.00
1	1	6/14	9	1.00	0.00	0.00	0.00	0.00	1.00
1	1	6/15	6	0.72	0.00	0.28	0.00	0.00	1.00
1	1	6/16	11	0.30	0.00	0.71	0.00	0.00	1.00
1	1	6/17	7	0.07	0.00	0.93	0.00	0.00	1.00
1	1	6/18	11	0.46	0.00	0.54	0.00	0.00	1.00
1	2	6/19	11	0.60	0.13	0.26	0.00	0.00	1.00
1	2	6/20	17	0.31	0.00	0.69	0.00	0.00	1.00
1	2	6/21	11	0.20	0.00	0.80	0.00	0.00	1.00
1	2	6/22	3	1.00	0.00	0.00	0.00	0.00	1.00
1	2	6/23	11	0.00	0.82	0.18	0.00	0.00	1.00
1	2	6/24	9	0.12	0.25	0.63	0.00	0.00	1.00
1	2	6/25	10	0.12	0.11	0.77	0.00	0.00	1.00
1	3	6/26	(246)	0.05	0.15	0.79	0.00	0.00	1.00
1	4	6/27	(133)	0.04	0.62	0.35	0.00	0.00	1.00
1	5	6/28	25	0.51	0.18	0.30	0.00	0.00	1.00
1	5	6/29	20	0.24	0.53	0.23	0.00	0.00	1.00
1	5	6/30	44	0.18	0.34	0.47	0.00	0.00	1.00
1	5	7/01	41	0.10	0.52	0.38	0.00	0.00	1.00
1	6	7/02	20	0.08	0.43	0.49	0.00	0.00	1.00
1	6	7/03	23	0.13	0.19	0.68	0.00	0.00	1.00
1	7	7/04	23	0.07	0.73	0.20	0.00	0.00	1.00
1	7	7/05	28	0.11	0.69	0.20	0.00	0.00	1.00
1	8	7/06	(221)	0.02	0.89	0.09	0.00	0.00	1.00
1	9	7/07	(267)	0.00	0.88	0.12	0.00	0.00	1.00
1	10	7/08	(113)	0.00	0.87	0.13	0.00	0.00	1.00
1	11	7/09	10	0.18	0.59	0.24	0.00	0.00	1.00
1	11	7/10	12	0.09	0.64	0.27	0.00	0.00	1.00
1	12	7/11	(463)	0.00	0.84	0.15	0.00	0.00	1.00
1	13	7/12	(660)	0.00	0.89	0.10	0.01	0.00	1.00
1	14	7/13	16	0.07	0.60	0.33	0.00	0.00	1.00
1	14	7/14	10	0.00	0.80	0.20	0.00	0.00	1.00
1	14	7/15	4	0.00	0.75	0.25	0.00	0.00	1.00
1	14	7/16	3	0.20	0.40	0.40	0.00	0.00	1.00
1	14	7/17	7	0.17	0.33	0.50	0.00	0.00	1.00
1	14	7/18	4	0.00	0.25	0.75	0.00	0.00	1.00
1	14	7/19	1	0.00	0.00	1.00	0.00	0.00	1.00
1	14	7/20	2	0.00	0.00	0.54	0.46	0.00	1.00
1	14	7/21	4	0.00	0.25	0.00	0.75	0.00	1.00
1	14	7/22	1	0.00	1.00	0.00	0.00	0.00	1.00
2	1	6/13	5	1.00	0.00	0.00	0.00	0.00	1.00
2	1	6/14	1	1.00	0.00	0.00	0.00	0.00	1.00
2	1	6/15	4	1.00	0.00	0.00	0.00	0.00	1.00
2	1	6/16	4	1.00	0.00	0.00	0.00	0.00	1.00
2	1	6/17	8	0.59	0.00	0.42	0.00	0.00	1.00
2	1	6/18	3	1.00	0.00	0.00	0.00	0.00	1.00
2	2	6/19	4	1.00	0.00	0.00	0.00	0.00	1.00
2	2	6/20	6	0.73	0.00	0.27	0.00	0.00	1.00
2	2	6/21	6	1.00	0.00	0.00	0.00	0.00	1.00
2	2	6/22	2	1.00	0.00	0.00	0.00	0.00	1.00
2	2	6/24	2	1.00	0.00	0.00	0.00	0.00	1.00
2	2	6/25	2	0.33	0.00	0.67	0.00	0.00	1.00
2	2	6/26	27	0.66	0.00	0.34	0.00	0.00	1.00
2	2	6/27	13	0.71	0.00	0.29	0.00	0.00	1.00
2	2	6/28	9	0.64	0.00	0.36	0.00	0.00	1.00

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Table 10. (p 2 of 3)

Counting[a] Range	Report Period	Date[b]	Catch[c]	Proportion of Catch					
				Chinook	Sockeye	Chum	Pink	Coho	Total
2	2	6/29	5	0.73	0.00	0.27	0.00	0.00	1.00
2	2	6/30	11	0.70	0.15	0.15	0.00	0.00	1.00
2	2	7/01	14	0.74	0.13	0.13	0.00	0.00	1.00
2	3	7/02	4	1.00	0.00	0.00	0.00	0.00	1.00
2	3	7/03	3	1.00	0.00	0.00	0.00	0.00	1.00
2	3	7/04	4	0.53	0.00	0.47	0.00	0.00	1.00
2	3	7/05	14	1.00	0.00	0.00	0.00	0.00	1.00
2	3	7/06	14	0.65	0.12	0.24	0.00	0.00	1.00
2	3	7/07	7	0.28	0.72	0.00	0.00	0.00	1.00
2	3	7/08	7	0.75	0.25	0.00	0.00	0.00	1.00
2	3	7/09	5	0.63	0.37	0.00	0.00	0.00	1.00
2	3	7/10	3	0.50	0.50	0.00	0.00	0.00	1.00
2	4	7/11	8	0.49	0.34	0.17	0.00	0.00	1.00
2	4	7/12	5	0.11	0.67	0.22	0.00	0.00	1.00
2	4	7/13	10	1.00	0.00	0.00	0.00	0.00	1.00
2	4	7/14	7	0.55	0.00	0.45	0.00	0.00	1.00
2	4	7/15	3	1.00	0.00	0.00	0.00	0.00	1.00
2	4	7/16	2	1.00	0.00	0.00	0.00	0.00	1.00
2	4	7/19	2	1.00	0.00	0.00	0.00	0.00	1.00
2	4	7/20	4	0.26	0.52	0.00	0.22	0.00	1.00
3	1	6/13	7	0.39	0.00	0.61	0.00	0.00	1.00
3	1	6/14	7	0.26	0.00	0.74	0.00	0.00	1.00
3	1	6/15	1	0.00	0.00	1.00	0.00	0.00	1.00
3	1	6/16	2	0.00	0.00	1.00	0.00	0.00	1.00
3	1	6/17	11	0.05	0.00	0.95	0.00	0.00	1.00
3	1	6/18	8	0.23	0.00	0.77	0.00	0.00	1.00
3	2	6/19	4	0.00	0.00	1.00	0.00	0.00	1.00
3	2	6/20	3	0.47	0.53	0.00	0.00	0.00	1.00
3	2	6/21	13	0.17	0.00	0.83	0.00	0.00	1.00
3	2	6/22	8	0.14	0.14	0.71	0.00	0.00	1.00
3	2	6/23	3	0.00	0.33	0.67	0.00	0.00	1.00
3	2	6/24	4	0.00	1.00	0.00	0.00	0.00	1.00
3	2	6/25	10	0.00	0.70	0.30	0.00	0.00	1.00
3	3	6/26	(93)	0.02	0.27	0.71	0.00	0.00	1.00
3	4	6/27	(141)	0.00	0.55	0.45	0.00	0.00	1.00
3	5	6/28	(104)	0.01	0.73	0.26	0.00	0.00	1.00
3	6	6/29	44	0.13	0.51	0.36	0.00	0.00	1.00
3	6	6/30	34	0.24	0.40	0.36	0.00	0.00	1.00
3	6	7/01	51	0.03	0.56	0.40	0.00	0.00	1.00
3	7	7/02	25	0.05	0.25	0.71	0.00	0.00	1.00
3	7	7/03	30	0.05	0.42	0.53	0.00	0.00	1.00
3	8	7/04	23	0.00	0.87	0.13	0.00	0.00	1.00
3	8	7/05	18	0.20	0.73	0.07	0.00	0.00	1.00
3	9	7/06	(257)	0.00	0.91	0.09	0.00	0.00	1.00
3	10	7/07	(161)	0.01	0.81	0.19	0.00	0.00	1.00
3	11	7/08	(150)	0.01	0.86	0.13	0.00	0.00	1.00
3	12	7/09	23	0.00	0.96	0.04	0.00	0.00	1.00
3	12	7/10	9	0.06	0.59	0.35	0.00	0.00	1.00
3	13	7/11	(313)	0.01	0.80	0.19	0.00	0.00	1.00
3	14	7/12	(533)	0.00	0.94	0.06	0.00	0.00	1.00
3	15	7/13	14	0.08	0.77	0.15	0.00	0.00	1.00
3	15	7/14	9	0.00	0.89	0.11	0.00	0.00	1.00
3	15	7/15	2	0.00	1.00	0.00	0.00	0.00	1.00
3	15	7/16	4	0.14	0.86	0.00	0.00	0.00	1.00
3	15	7/17	5	0.00	0.60	0.40	0.00	0.00	1.00
3	15	7/18	2	0.00	0.53	0.00	0.47	0.00	1.00
3	15	7/19	5	0.00	1.00	0.00	0.00	0.00	1.00

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Table 10. (p 3 of 3)

Counting[a] Range	Report Period	Date[b]	Catch[c]	Proportion of Catch					
				Chinook	Sockeye	Chum	Pink	Coho	Total
3	15	7/20	3	0.00	1.00	0.00	0.00	0.00	1.00
3	15	7/21	6	0.00	0.17	0.33	0.51	0.00	1.00
3	15	7/22	2	0.00	0.00	0.49	0.51	0.00	1.00
4	1	6/13	3	1.00	0.00	0.00	0.00	0.00	1.00
4	1	6/15	1	1.00	0.00	0.00	0.00	0.00	1.00
4	1	6/16	4	0.33	0.00	0.67	0.00	0.00	1.00
4	1	6/17	4	0.15	0.00	0.85	0.00	0.00	1.00
4	1	6/18	1	1.00	0.00	0.00	0.00	0.00	1.00
4	2	6/20	1	1.00	0.00	0.00	0.00	0.00	1.00
4	2	6/21	3	0.25	0.00	0.75	0.00	0.00	1.00
4	2	6/24	3	0.20	0.00	0.80	0.00	0.00	1.00
4	2	6/26	13	0.27	0.00	0.73	0.00	0.00	1.00
4	2	6/27	20	0.15	0.28	0.57	0.00	0.00	1.00
4	2	6/28	6	0.50	0.25	0.25	0.00	0.00	1.00
4	2	6/29	10	0.11	0.45	0.45	0.00	0.00	1.00
4	2	6/30	15	0.37	0.18	0.45	0.00	0.00	1.00
4	2	7/01	18	0.14	0.19	0.68	0.00	0.00	1.00
4	2	7/02	4	0.00	0.00	1.00	0.00	0.00	1.00
4	3	7/03	8	0.15	0.43	0.43	0.00	0.00	1.00
4	3	7/04	3	0.16	0.42	0.42	0.00	0.00	1.00
4	3	7/05	14	0.21	0.62	0.18	0.00	0.00	1.00
4	3	7/06	10	0.42	0.43	0.15	0.00	0.00	1.00
4	3	7/07	7	0.07	0.77	0.15	0.00	0.00	1.00
4	3	7/08	3	1.00	0.00	0.00	0.00	0.00	1.00
4	3	7/10	2	0.00	0.50	0.50	0.00	0.00	1.00
4	4	7/11	9	0.31	0.27	0.41	0.00	0.00	1.00
4	4	7/12	4	0.14	0.57	0.29	0.00	0.00	1.00
4	4	7/13	11	0.05	0.76	0.19	0.00	0.00	1.00
4	4	7/14	4	0.14	0.57	0.29	0.00	0.00	1.00
4	4	7/15	2	0.00	1.00	0.00	0.00	0.00	1.00
4	4	7/16	1	1.00	0.00	0.00	0.00	0.00	1.00
4	4	7/19	1	0.00	1.00	0.00	0.00	0.00	1.00
4	4	7/20	2	0.50	0.50	0.00	0.00	0.00	1.00
4	4	7/21	1	0.00	0.00	0.00	1.00	0.00	1.00

[a] Counting Range: 1=left inshore, 2=left offshore, 3=right inshore, 4=right offshore

[b] Data are omitted for dates on which no fish were caught in that counting range.

[c] Beach seine catches in parentheses.

Table 11. Comparison of species apportionment estimates using different report periods, Nushagak River sonar project, 1992.

Report Period Criteria	Number of Salmon				
	Chinook	Sockeye	Chum	Pink	Total
Sample Size >100 or 7 d	81,713	688,680	310,423	8,418	1,089,234
Sample size >100	82,886	690,254	307,702	8,392	1,089,234
% Difference	1.4	0.2	0.9	0.3	
Sample Size >100 or 7 d	81,713	688,680	310,423	8,418	1,089,234
Sample size >100 or change in species composition	82,848	695,108	302,678	8,600	1,089,234
% Difference	1.4	0.9	2.5	2.2	
Sample size >100	82,886	690,254	307,702	8,392	1,089,234
Sample size >100 or change in species composition	82,848	695,108	302,678	8,600	1,089,234
% Difference	0.0	0.7	1.7	2.4	

Table 12. Final escapement estimates by species, Nushagak River sonar project, 1992.

Date	Sockeye Daily	Sockeye Cum.	Chinook Daily	Chinook Cum.	Chum Daily	Chum Cum.	Pink Daily	Pink Cum.	Coho Daily	Coho Cum.	Total Daily	Total Cum.
6/09	0	0	124	124	253	253	0	0	0	0	377	377
6/10	0	0	105	229	275	528	0	0	0	0	380	757
6/11	0	0	110	339	178	706	0	0	0	0	288	1,045
6/12	0	0	140	479	245	951	0	0	0	0	385	1,430
6/13	0	0	1,567	2,046	2,377	3,328	0	0	0	0	3,944	5,374
6/14	0	0	1,138	3,184	1,719	5,047	0	0	0	0	2,857	8,231
6/15	0	0	715	3,899	993	6,040	0	0	0	0	1,708	9,939
6/16	0	0	1,177	5,076	2,308	8,348	0	0	0	0	3,485	13,424
6/17	0	0	2,841	7,917	6,097	14,445	0	0	0	0	8,938	22,362
6/18	0	0	3,607	11,524	7,379	21,824	0	0	0	0	10,986	33,348
6/19	915	915	852	12,376	2,012	23,836	0	0	0	0	3,779	37,127
6/20	1,132	2,047	967	13,343	2,547	26,383	0	0	0	0	4,646	41,773
6/21	1,811	3,858	1,765	15,108	4,249	30,632	0	0	0	0	7,825	49,598
6/22	1,594	5,452	1,388	16,496	3,582	34,214	0	0	0	0	6,564	56,162
6/23	951	6,403	895	17,391	2,174	36,388	0	0	0	0	4,020	60,182
6/24	999	7,402	959	18,350	2,299	38,687	0	0	0	0	4,257	64,439
6/25	1,379	8,781	1,047	19,397	2,922	41,609	0	0	0	0	5,348	69,787
6/26	20,836	29,617	8,043	27,440	70,147	111,756	0	0	0	0	99,026	168,813
6/27	35,478	65,095	4,726	32,166	30,596	142,352	0	0	0	0	70,800	239,613
6/28	32,522	97,617	4,428	36,594	16,681	159,033	0	0	0	0	53,631	293,244
6/29	14,576	112,193	5,354	41,948	12,887	171,920	0	0	0	0	32,817	326,061
6/30	18,597	130,790	7,036	48,984	15,887	187,807	0	0	0	0	41,520	367,581
7/01	12,759	143,549	5,534	54,518	11,156	198,963	0	0	0	0	29,449	397,030
7/02	5,701	149,250	1,704	56,222	9,764	208,727	0	0	0	0	17,169	414,199
7/03	3,239	152,489	1,207	57,429	5,103	213,830	0	0	0	0	9,549	423,748
7/04	19,927	172,416	2,254	59,683	3,527	217,357	0	0	0	0	25,708	449,456
7/05	22,121	194,537	2,563	62,246	3,768	221,125	0	0	0	0	28,452	477,908
7/06	63,871	258,408	3,300	65,546	6,615	227,740	0	0	0	0	73,786	551,694
7/07	71,122	329,530	1,683	67,229	13,815	241,555	0	0	0	0	86,620	638,314
7/08	36,090	365,620	1,482	68,711	5,897	247,452	0	0	0	0	43,469	681,783
7/09	12,242	377,862	1,538	70,249	3,022	250,474	0	0	0	0	16,802	698,585
7/10	9,580	387,442	1,243	71,492	2,360	252,834	0	0	0	0	13,183	711,768
7/11	89,913	477,355	2,568	74,060	19,174	272,008	568	568	0	0	112,223	823,991
7/12	173,110	650,465	2,774	76,834	14,505	286,513	1,465	2,033	0	0	191,854	1,015,845
7/13	17,703	668,168	1,823	78,657	6,202	292,715	2,625	4,658	0	0	28,353	1,044,198
7/14	8,591	676,759	1,074	79,731	3,027	295,742	1,262	5,920	0	0	13,954	1,058,152
7/15	4,679	681,438	725	80,456	1,603	297,345	684	6,604	0	0	7,691	1,065,843
7/16	3,525	684,963	698	81,154	1,351	298,696	517	7,121	0	0	6,091	1,071,934

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Table 12. (p 2 of 2)

Date	Sockeye Daily	Sockeye Cum.	Chinook Daily	Chinook Cum.	Chum Daily	Chum Cum.	Pink Daily	Pink Cum.	Coho Daily	Coho Cum.	Total Daily	Total Cum.
7/17	2,895	687,858	512	81,666	1,225	299,921	423	7,544	0	0	5,055	1,076,989
7/18	1,559	689,417	431	82,097	614	300,535	222	7,766	0	0	2,826	1,079,815
7/19	1,417	690,834	317	82,414	550	301,085	205	7,971	0	0	2,489	1,082,304
7/20	1,433	692,267	211	82,625	548	301,633	210	8,181	0	0	2,402	1,084,706
7/21	2,016	694,283	177	82,802	755	302,388	295	8,476	0	0	3,243	1,087,949
7/22	825	695,108	46	82,848	290	302,678	124	8,600	0	0	1,285	1,089,234
Total	695,108		82,848		302,678		8,600		0		1,089,234	

Table 13. Sockeye salmon escapement estimates and average escapement proportion by day, Nushagak River, 1980 - 1992.

	Year													Average Proportion[a]	
Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Daily	Cumulative
6/04					149									0.02	0.02
6/05					457		0					74		0.05	0.07
6/06					574		0	0		2	11	126		0.02	0.09
6/07					591		3	0	2	4	11	94		0.02	0.11
6/08					622		2	0	3	3	32	80		0.02	0.13
6/09					624		3	0	11	14	145	74		0.02	0.15
6/10					450		15	0	25	19	33	114		0.01	0.16
6/11			0	253	385	19	6	0	18	9	23	79		0.02	0.18
6/12		243	0	335	254	5	15	0	5	23	15	87		0.03	0.21
6/13		457	0	454	362	42	71	0	6	25	52	75		0.04	0.25
6/14		420	120	282	787	48	76	0	4	23	37	71		0.03	0.28
6/15		323	252	437	1,440	7	32	0	106	25	149	866		0.07	0.35
6/16		573	239	297	1,528	6	37	0	185	24	117	2,360		0.09	0.44
6/17		1,514	614	282	3,478	4	16	332	71	78	51	836		0.11	0.55
6/18		972	678	306	1,380	8	14	540	50	114	43	770		0.08	0.63
6/19		893	481	292	2,519	82	112	301	41	21	47	443	915	0.09	0.73
6/20		1,247	338	790	1,544	3,124	141	217	65	64	0	677	1,132	0.19	0.92
6/21		5,134	0	606	1,019	2,616	88	115	27	361	0	860	1,811	0.21	1.12
6/22	352	3,426	7,133	3,385	3,030	915	119	145	28	1,082	995	1,457	1,594	0.41	1.54
6/23	476	2,490	23,182	1,653	3,475	1,698	229	154	50	1,372	5,297	3,088	951	0.66	2.20
6/24	528	239	39,230	5,455	11,295	369	270	740	54	3,460	1,960	10,144	999	1.21	3.41
6/25	737	0	7,133	2,890	83,644	229	1,091	3,275	8,697	15,260	1,009	11,286	1,379	1.96	5.36
6/26	1,339	0	0	3,749	54,222	419	3,392	4,456	19,752	36,432	320	10,463	20,836	2.25	7.61
6/27	1,670	195	8,916	4,125	48,318	421	4,282	2,145	15,167	24,731	355	8,926	35,478	2.17	9.79
6/28	268	1,701	21,398	9,926	14,201	305	1,583	4,039	16,237	14,893	1,540	11,075	32,522	2.06	11.85
6/29	111	3,287	14,266	4,826	18,904	908	853	16,046	5,819	3,495	1,935	29,203	14,576	1.81	13.66
6/30	3,688	6,143	16,049	7,235	44,465	1,400	946	47,423	2,392	37,613	1,604	15,961	18,597	3.24	16.90
7/01	25,625	76,193	41,014	9,534	31,261	53,282	5,874	66,559	1,466	34,028	9,858	62,496	12,759	6.66	23.56
7/02	104,306	41,641	37,447	9,224	58,296	35,792	9,468	84,275	1,708	57,488	85,624	30,292	5,701	7.75	31.31
7/03	240,530	52,501	35,664	4,781	22,133	18,234	5,414	39,477	4,345	55,416	55,341	88,577	3,239	7.29	38.61
7/04	294,491	82,221	32,098	8,079	8,840	13,382	18,067	19,411	45,767	106,391	23,207	100,822	19,927	8.89	47.50
7/05	222,282	223,247	30,314	28,917	37,884	13,210	34,648	9,143	42,967	15,922	8,977	35,766	22,121	8.40	55.90
7/06	97,701	150,089	37,447	10,492	55,571	16,440	44,969	5,523	10,097	14,731	34,852	4,094	63,871	6.23	62.13
7/07	54,034	25,267	23,182	7,959	15,876	12,124	57,760	5,930	11,032	19,106	314,041	2,228	71,122	7.23	69.36
7/08	23,484	22,271	24,965	8,792	14,680	21,881	46,419	18,647	11,348	12,635	56,812	1,641	36,090	4.05	73.41
7/09	9,973	22,068	5,350	6,926	14,618	19,258	41,217	22,710	52,969	5,812	10,124	1,306	12,242	3.33	76.73
7/10	9,223	42,360	7,133	5,818	15,366	10,439	104,907	2,918	57,393	9,242	4,864	1,809	9,580	3.55	80.28
7/11	4,603	22,629	14,266	3,063	5,264	6,703	144,139	1,025	57,062	3,442	2,752	3,342	89,913	4.22	84.50

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Table 13. (p 2 of 3)

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Average Proportion* Daily	Cumulative
7/12	4,355	12,296	8,916	3,059	3,175	8,538	125,352	1,370	85,645	12,543	7,528	4,810	173,110	5.47	89.97
7/13	4,519	6,774	12,482	2,338	1,465	5,459	68,323	1,095	11,291	4,313	6,579	2,073	17,703	1.74	91.71
7/14	5,539	3,517	5,350	3,055	909	11,785	20,310	899	2,097	4,903	3,799	2,984	8,591	1.07	92.78
7/15	3,121	1,213	5,350	3,180	691	22,640	7,280	2,286	857	2,713	3,165	2,185	4,679	1.08	93.86
7/16	2,891	343	7,133	3,018	803	12,476	17,099	2,044	888	1,946	2,129	3,716	3,525	0.93	94.79
7/17	9,681		10,699	1,546	1,912	8,491	8,942	1,932	1,891	2,692	1,953	6,206	2,895	0.92	95.71
7/18	7,883		7,133	1,739	532	7,469	3,798	2,316	1,877	4,090	1,319	7,250	1,559	0.79	96.50
7/19	920		16,049	1,688	393	2,708	4,005	2,121	816	1,477	845	7,552	1,417	0.69	97.19
7/20	1,031		5,350	1,823	671	928	2,255	2,920	1,532	1,223	883	3,914	1,433	0.43	97.62
7/21	1,084		7,133	271	966	1,616	1,820	5,435	2,286	1,294	1,206	2,408	2,016	0.46	98.08
7/22	0		5,350	280	733	1,484	878	2,197	2,219	376	2,785	3,854	825	0.35	98.43
7/23	0		7,133	326	124	1,226	2,273	1,082	442	387	3,579	2,516		0.33	98.76
7/24	0		7,133	343	368	395	3,589	1,312	639	413	3,278	575		0.30	99.06
7/25	0		1,783	424	338	1,402	2,015	886	911	277	483	16		0.17	99.23
7/26	0		1,783	398	286	898	1,370	896	275	148	572	15		0.13	99.36
7/27	0		0	395	0	658	2,557	832	254	75	600	16		0.10	99.46
7/28	0		0	422	0	258	329	530	208	90	788	62		0.06	99.53
7/29	0		0	429	0	42	847	400	163	84	1,204	224		0.07	99.59
7/30	0		0	275	0	36	182	462	343	177	1,220	102		0.06	99.65
7/31	0		0	0	0	47	60	289	645	502	763	33		0.04	99.69
8/01	0		0	0	0	37	205	276	410	128	130	32		0.02	99.71
8/02	0		0	0	0	36	248	311	0	38	138	61		0.01	99.72
8/03	0		0	0	0	42	0	248	0	45	735	25		0.02	99.74
8/04	0		0	0	0	142	663	23	0	29	188	21		0.02	99.76
8/05	0		0	0	0	0	322	61	285	25	1,175	13		0.03	99.78
8/06	0		0	0	0	0	178	103	294	35	2,993	26		0.05	99.83
8/07			0	0	0	0	69	50	355	38	1,788	13		0.04	99.87
8/08			0	0	0	0	58	20	476	0	5,030	7		0.08	99.96
8/09			0	0	0	18	52	8	279	0	867	9		0.02	99.98
8/10			0	341	0	11	98	13	140	0	0	14		0.02	100.00
8/11			0	152	0	6	193	8	132	0	0	17			
8/12			0	125	0	26	224	11	211	0	0	22			
8/13			0	94	0	21	123	14	71	0	236	18			
8/14			0	73	0	37	195	7	79	0	177	24			
8/15			0	76	0	10	67	12	43	0	0	25			
8/16			0	66	0	5	31	9	36	0	0	8			
8/17			0	42	0	2	38	10	62	0	0	3			
8/18			0		0	2			31	0	0	5			

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Table 13. (p 3 of 3)

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Average Proportion[a]	
														Daily	Cumulative
8/19					0	2			13	0	0	2			
8/20					0	3			9	0	0	3			
8/21					0	1			15	0	0	1			
8/22					0				6	0	0				
8/23					0				5	0	0				
8/24					0					0	0				
8/25					0					0	0				
Total	1,136,445	813,887	537,686	177,141	592,872	322,327	802,326	388,034	483,200	513,421	680,368	495,106	695,108		

[a] Average proportions for 1980 - 1992, June 4 through August 10.

Table 14. Age, sex, and size composition of sockeye salmon escapement, Nushagak River sonar project, 1992.

				Age Group					
	0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	Total
Sample Period 1: 19 June - 7 July									
Males	21,746	31,364	33,455	10,036	46,836	1,673	10,873	4,182	160,165
Percent	6.60	9.52	10.15	3.05	14.21	0.51	3.30	1.27	48.60
Sample Size	52	75	80	24	112	4	26	10	383
Mean Length	411	533	462	603	544	481	588	557	513
Std. Error	3	6	6	6	4	50	7	19	2
Sample Size	51	75	80	24	112	3	26	10	381
Females	2,927	28,855	24,673	25,091	61,891	1,255	21,746	2,927	169,365
Percent	0.89	8.76	7.49	7.61	18.78	0.38	6.60	0.89	51.40
Sample Size	7	69	59	60	148	3	52	7	405
Mean Length	427	529	476	566	528	485	565	528	529
Std. Error	11	2	4	2	2	83	3	8	1
Sample Size	7	68	58	59	148	2	51	7	400
Both Sexes	24,673	60,219	58,128	35,127	108,727	2,928	32,619	7,109	329,530
Percent	7.49	18.27	17.64	10.66	32.99	0.89	9.90	2.16	100.00
Sample Size	59	144	139	84	260	7	78	17	788
Mean Length	413	531	468	576	535	483	572	545	521
Std. Error	3	3	4	2	2	46	3	12	1
Sample Size	58	143	138	83	260	5	77	17	781
Sample Period 2: 8 - 22 July									
Males	24,137	31,177	26,149	12,571	53,807	3,017	16,091	5,531	172,480
Percent	6.60	8.53	7.15	3.44	14.72	0.83	4.40	1.51	47.18
Sample Size	48	62	52	25	107	6	32	11	343
Mean Length	414	565	454	604	563	519	606	565	532
Std. Error	4	5	7	6	3	23	5	12	2
Sample Size	48	60	52	24	106	6	32	11	339
Females	503	49,783	29,166	22,126	62,857	1,509	21,623	5,531	193,098
Percent	0.14	13.62	7.98	6.05	17.19	0.41	5.91	1.51	52.82
Sample Size	1	99	58	44	125	3	43	11	384
Mean Length	430	530	479	572	528	489	562	538	530
Std. Error		2	3	3	3	4	6	5	1
Sample Size	1	99	58	44	123	3	43	11	382
Both Sexes	24,640	80,960	55,315	34,697	116,664	4,526	37,714	11,062	365,578
Percent	6.74	22.15	15.13	9.49	31.91	1.24	10.32	3.03	100.00
Sample Size	49	161	110	69	232	9	75	22	727
Mean Length	415	543	467	583	544	509	581	552	531
Std. Error	4	3	4	3	2	15	4	6	1
Sample Size	49	159	110	68	229	9	75	22	721

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Table 14. (p 2 of 2).

	Age Group								Total
	0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3	
All Periods Combined:									
Males	45,883	62,541	59,604	22,607	100,643	4,690	26,964	9,713	332,645
Percent	6.60	9.00	8.57	3.25	14.48	0.67	3.88	1.40	47.86
Sample Size	100	137	132	49	219	10	58	21	726
Mean Length	413	549	458	603	554	505	599	562	523
Std. Error	2	4	4	4	3	23	4	10	2
Sample Size	99	135	132	48	218	9	58	21	720
Females	3,430	78,638	53,839	47,217	124,748	2,764	43,369	8,458	362,463
Percent	0.49	11.31	7.75	6.79	17.95	0.40	6.24	1.22	52.14
Sample Size	8	168	117	104	273	6	95	18	789
Mean Length	427	529	478	568	528	487	563	534	529
Std. Error	11	2	2	2	2	38	3	4	1
Sample Size	8	167	116	103	271	5	94	18	782
Both Sexes	49,313	141,179	113,443	69,824	225,391	7,454	70,333	18,171	695,108
Percent	7.09	20.31	16.32	10.05	32.43	1.07	10.12	2.61	100.00
Sample Size	108	305	249	153	492	16	153	39	1,515
Mean Length	414	538	468	580	539	498	577	549	526
Std. Error	2	2	3	2	1	20	3	6	1
Sample Size	107	302	248	151	489	14	152	39	1,502

Table 15.   Chinook salmon escapement estimates and average escapement proportion by day, Nushagak River, 1980 - 1992.

	Year												Average Proportion[a]	
Date	1980	1981	1982	1983	1985	1986	1987	1988	1989	1990	1991	1992	Daily	Cumulative
6/05											106		0.10	0.10
6/06						1	45		2	63	164		0.06	0.17
6/07						9	153	115	4	64	118		0.10	0.27
6/08						6	158	165	3	136	119		0.14	0.41
6/09						11	1,676	336	14	386	121	124	0.50	0.91
6/10						51	1,441	916	19	151	159	105	0.57	1.48
6/11				118	44	41	640	873	9	108	139	110	0.33	1.81
6/12		1,128		156	9	82	760	186	23	94	164	140	0.23	2.04
6/13		2,124		212	112	318	446	205	25	241	138	1,567	0.49	2.53
6/14		1,951	281	131	148	297	507	143	23	166	120	1,138	0.40	2.93
6/15		1,500	589	204	33	101	657	1,875	25	2,468	1,214	715	1.16	4.10
6/16		2,660	557	139	24	148	366	5,078	24	1,953	4,751	1,177	2.10	6.21
6/17		909	1,432	132	14	43	2,048	1,359	138	844	2,332	2,841	1.36	7.57
6/18		584	1,583	143	20	72	2,943	874	188	712	2,008	3,607	1.44	9.02
6/19		568	1,123	136	371	424	1,407	570	64	788	1,201	852	0.85	9.87
6/20		14	790	368	2,627	789	883	1,084	109	542	923	967	1.20	11.08
6/21		56	7,836	570	3,886	525	678	613	450	1,374	1,166	1,765	1.50	12.58
6/22	3,975	2,056	5,746	3,180	1,755	521	724	449	1,746	10,709	1,888	1,388	3.35	15.95
6/23	5,377	3,556	6,791	1,553	3,557	188	611	781	2,712	4,692	4,199	895	2.61	18.57
6/24	1,463	7,500	17,239	5,124	888	274	14,082	1,279	5,876	1,729	19,352	959	6.15	24.74
6/25	2,040	11,472	4,179	2,715	380	516	10,196	6,334	2,561	890	10,207	1,047	4.79	29.55
6/26	3,707	7,049	2,612	4,388	645	643	2,340	4,292	5,973	285	7,721	8,043	4.65	34.22
6/27	4,623	5,592	1,567	4,828	1,761	999	1,296	2,481	1,257	313	3,502	4,726	2.86	37.09
6/28	3,661	1,625	1,567	11,618	1,716	750	2,215	1,980	838	264	4,555	4,428	3.55	40.66
6/29	1,524	3,140	3,134	5,649	604	405	5,444	2,486	2,167	332	10,129	5,354	4.14	44.81
6/30	1,553	3,909	5,224	8,468	907	443	2,179	1,007	1,521	283	5,290	7,036	3.38	48.20
7/01	1,875	2,432	5,746	5,742	9,184	128	7,369	536	395	1,428	1,884	5,534	4.00	52.22
7/02	4,688	21,917	5,746	5,556	15,016	181	1,612	700	417	5,317	1,081	1,704	4.00	56.24
7/03	2,702	14,789	5,224	2,880	6,527	187	3,448	1,612	6	2,350	1,326	1,207	2.57	58.82
7/04	2,777	10,517	1,045	4,866	4,291	82	1,581	3,519	1,386	1,857	2,517	2,254	3.01	61.84
7/05	2,850	5,773	4,179	4,876	4,074	782	781	3,339	2,614	724	1,431	2,563	2.93	64.78
7/06	2,252	3,400	4,179	1,769	5,850	1,249	399	625	2,812	1,171	1,316	3,300	2.53	67.31
7/07	2,052	2,214	3,657	1,342	4,023	2,256	565	684	3,861	2,579	664	1,683	2.67	69.99
7/08	602	1,028	1,567	1,482	3,217	1,990	1,922	705	2,817	10,211	518	1,482	3.85	73.86
7/09	285	1,720	2,090	1,168	2,752	2,192	1,508	0	1,104	2,301	379	1,538	2.00	75.86
7/10	784	1,880	3,134	981	2,886	1,843	235	0	1,905	1,636	398	1,243	1.70	77.56
7/11	1,284	1,880	1,567	2,351	2,192	1,111	462	0	1,059	433	791	2,568	1.50	79.06
7/12	917	2,049	2,612	2,347	1,222	3,891	641	2,663	6,996	643	1,397	2,774	3.61	82.69
7/13	1,010	1,103	2,090	1,794	829	1,247	502	509	2,408	619	390	1,823	1.51	84.20
7/14	1,108	959	2,090	2,345	1,880	1,447	407	724	1,591	447	468	1,074	1.52	85.73
7/15	624	934	4,702	2,440	4,016	3,045	1,074	296	2,527	179	386	725	2.22	87.96

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Table 15.   (p 2 of 2)

	Year												Average	Proportion[a]
Date	1980	1981	1982	1983	1985	1986	1987	1988	1989	1990	1991	1992	Daily	Cumulative
7/16	662	264	1,567	755	2,000	1,166	937	307	2,070	157	543	698	1.26	89.22
7/17	2,689	0	2,090	387	1,718	3,097	890	653	2,186	281	838	512	1.79	91.02
7/18	5,101	0	2,090	435	1,631	1,146	1,069	648	3,628	243	953	431	1.51	92.53
7/19	595	0	522	422	2,389	1,176	947	282	1,420	25	1,117	317	1.16	93.70
7/20	0	0	1,045	456	951	936	743	529	1,828	30	637	211	0.96	94.66
7/21	0	0	522	361	493	738	1,399	788	1,619	51	531	177	0.94	95.60
7/22	0	0	1,567	373	477	398	509	766	795	114	1,245	46	0.68	96.29
7/23	0	0	522	435	371	288	224	89	728	127	580		0.45	96.73
7/24	0	0	1,045	458	119	808	269	102	1,106	131	177		0.59	97.32
7/25	0	0	1,500	566	522	463	168	229	748	364	19		0.54	97.86
7/26	0	0	2,090	597	319	618	157	91	452	208	20		0.45	98.31
7/27	0	0	0	592	234	1,168	158	78	317	94	18		0.55	98.86
7/28	0	0	0	633	104	120	90	111	372	531	62		0.33	99.20
7/29	0	0	0	644	29	0	68	79	327	37	244		0.20	99.39
7/30	0	0	0	413	17	182	77	142	517	22	207		0.26	99.65
7/31	0	0	0	957	27	60	51	87	1,098	12	47		0.35	100.00
8/01	0	0	0	660	26	50	44	95	474	0	34			
8/02	0	0	0	790	18	0	61	0	205	46	64			
8/03	0	0	0	734	24	0	47	436	362	0	31			
8/04	0	0	0	658	62	787	0	0	170	0	23			
8/05	0	0	0	55	0	381	0	0	59	0	18			
8/06	0	0	0	89	0	204	0	0	57	0	28			
8/07		0	0	83	0	87	0	0	95	0	12			
8/08		0	0	211	0	72	0	0	0	0	8			
8/09		0	0	232	0	66	0	0	0	0	11			
8/10		0	0	0	0	135	0	0	0	0	27			
8/11		0	0	0	0	0	0	0	0	0	28			
8/12		0	0	0	0	0	0	0	0	0	28			
8/13		0	0	0	0	0	0	0	0	0	14			
8/14		0	0	0	0	0	0	0	0	0	9			
8/15		0	0	0	0	0	0	0	0	0	8			
8/16		0	0	0	0	0	0	0	0	0	16			
8/17		0	0								7			
8/18		0									7			
8/19						0			0	0	3			
8/20						0			0	0	4			
8/21						0			0	0	1			
Total	62,780	130,252	126,438	103,767	98,991	43,434	84,309	56,905	78,302	63,955	104,351	82,848		

[a] Average proportions for 1983, 1985 - 1992, June 5 through July 31.

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Table 16. Age, sex, and size composition of chinook salmon escapement, Nushagak River sonar project, 1992.

				Age Group					
	0.2	1.1	1.2	1.3	1.4	2.3	1.5	2.4	Total
Males	140	1,537	15,787	16,065	7,405	140	140		41,214
Percent	0.17	1.86	19.06	19.39	8.94	0.17	0.17		49.75
Sample Size	1	11	113	115	53	1	1		295
Mean Length	434	390	566	739	883	788	909		685
Std. Error		8	5	9	9				4
Sample Size	1	10	112	114	53	1	1		292
Females			6,985	14,390	19,420	140	559	140	41,634
Percent			8.43	17.37	23.44	0.17	0.67	0.17	50.25
Sample Size			50	103	139	1	4	1	298
Mean Length			580	744	872	734	976	949	780
Std. Error			5	8	5		49		4
Sample Size			49	103	137	1	4	1	295
Both Sexes	140	1,537	22,772	30,455	26,825	280	699	140	82,848
Percent	0.17	1.86	27.49	36.76	32.38	0.34	0.84	0.17	100.00
Sample Size	1	11	163	218	192	2	5	1	593
Mean Length	434	390	570	741	875	761	963	949	733
Std. Error		8	4	6	4		49		3
Sample Size	1	10	161	217	190	2	5	1	587

Table 17. Chum salmon escapement estimates and average escapement proportion by day, Nushagak River, 1980 - 1992.

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Daily	Cumulative
														Average	Proportion[a]
6/04					100									0.03	0.03
6/05					305		0					110		0.04	0.07
6/06					383		1	9		2	35	183		0.03	0.10
6/07					394		8	19	65	128	36	144		0.04	0.13
6/08					415		5	22	94	149	88	124		0.04	0.17
6/09					416		6	152	205	103	322	119	253	0.07	0.25
6/10					300		37	150	545	112	94	170	275	0.09	0.33
6/11			0	0	257	3	8	63	501	11	66	124	178	0.05	0.38
6/12		364	0	0	289	0	25	127	112	31	51	135	245	0.05	0.43
6/13		686	0	0	328	9	139	68	123	44	149	117	2,377	0.14	0.57
6/14		630	100	0	524	17	166	53	85	106	104	112	1,719	0.12	0.69
6/15		485	210	0	960	6	79	57	2,650	71	2,191	1,211	993	0.30	0.99
6/16		859	199	0	1,018	4	80	37	5,774	127	1,691	3,354	2,308	0.54	1.53
6/17		330	512	0	331	2	40	786	1,839	127	747	1,169	6,097	0.39	1.92
6/18		212	565	0	1,380	1	25	1,313	1,241	180	618	1,024	7,379	0.44	2.36
6/19		162	401	0	504	66	245	751	924	48	665	627	2,012	0.22	2.58
6/20		95	282	0	309	6,283	220	553	1,579	103	1,627	941	2,547	0.51	3.09
6/21		391	3,895	487	29	3,209	126	274	764	1,377	4,766	1,190	4,249	0.67	3.76
6/22	704	3,084	3,895	2,718	19	1,414	235	357	666	4,053	61,168	2,159	3,582	2.23	6.00
6/23	953	2,845	1,948	1,327	2,824	2,846	509	394	1,181	5,035	13,549	4,678	2,174	1.17	7.17
6/24	2,072	239	7,790	4,380	7,530	703	757	8,520	1,549	12,896	5,180	37,121	2,299	2.75	9.92
6/25	2,890	1,275	5,194	2,321	13,207	310	6,649	24,484	37,375	13,309	2,668	13,765	2,922	4.59	14.51
6/26	5,252	2,106	14,282	2,939	26,651	531	7,461	9,730	24,871	37,152	787	12,980	70,147	6.18	20.68
6/27	6,550	715	12,335	3,235	23,750	1,354	9,871	4,533	6,206	19,834	942	10,142	30,596	3.74	24.43
6/28	5,001	454	10,387	7,783	67,031	1,306	12,630	8,737	6,181	11,501	152	12,072	16,681	4.71	29.14
6/29	2,081	876	1,948	3,784	89,225	347	6,843	2,225	1,784	12,653	190	20,662	12,887	3.92	33.05
6/30	1,229	1,117	7,790	5,673	17,242	541	7,480	16,250	750	14,558	137	11,025	15,887	3.30	36.36
7/01	3,750	2,432	9,738	1,733	10,212	18,749	2,843	26,278	551	17,800	37,878	5,882	11,156	4.68	41.04
7/02	8,204	9,497	7,141	1,677	8,093	27,024	4,135	12,608	556	23,527	28,403	4,831	9,764	4.51	45.55
7/03	27,026	6,655	21,424	869	17,438	9,186	2,117	5,688	1,607	25,766	23,937	20,793	5,103	4.61	50.16
7/04	60,317	2,868	6,492	1,469	6,965	6,889	2,568	2,335	8,898	35,698	6,148	57,021	3,527	5.27	55.43
7/05	59,845	4,556	5,194	8,238	11,430	6,848	7,630	1,246	7,069	11,076	2,364	17,481	3,768	4.36	59.79
7/06	36,136	4,642	2,597	2,989	4,015	8,293	3,154	472	2,746	9,763	19,729	1,546	6,615	2.87	62.66
7/07	12,312	32,159	3,246	2,267	9,355	6,201	1,128	440	2,981	12,403	19,224	936	13,815	3.91	66.57
7/08	6,021	10,964	9,089	2,505	7,234	7,338	4,644	1,311	3,053	7,878	28,154	739	5,897	2.97	69.54
7/09	3,989	4,872	3,895	1,973	3,765	6,601	5,551	2,532	1,135	7,435	6,448	559	3,022	1.74	71.28
7/10	2,755	11,948	7,141	1,657	2,561	5,348	11,008	574	6,152	11,640	10,333	780	2,360	2.61	73.89
7/11	4,817	6,383	8,440	3,205	2,507	4,401	8,089	301	6,382	6,060	3,337	1,366	19,174	2.51	76.40

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Table 17. (p 2 of 3)

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Average Proportion[a] Daily	Average Proportion[a] Cumulative
7/12	6,189	6,149	8,440	3,201	0	1,178	27,386	333	24,133	16,412	2,854	1,706	14,505	4.04	80.43
7/13	4,895	7,877	9,089	2,447	932	746	7,314	295	5,310	5,646	2,472	1,580	6,202	1.97	82.40
7/14	4,431	6,180	2,597	3,198	578	1,596	2,138	258	840	5,343	1,035	2,223	3,027	1.22	83.62
7/15	2,496	7,187	2,597	3,327	440	18,524	4,709	540	368	6,137	564	1,646	1,603	1.89	85.51
7/16	3,572	2,030	2,597	2,910	511	10,549	5,500	552	379	4,551	436	2,752	1,351	1.36	86.87
7/17	14,521		3,895	1,491	1,217	4,898	2,933	509	756	5,902	612	4,559	1,225	1.34	88.21
7/18	31,534		7,141	1,677	5,322	4,215	1,223	606	667	9,144	496	5,325	614	1.94	90.15
7/19	3,680		5,843	1,628	4,716	20,261	1,284	650	296	3,366	651	5,615	550	1.68	91.83
7/20	4,122		8,440	1,758	1,343	5,744	1,481	1,037	531	4,094	702	2,938	548	1.14	92.98
7/21	4,334		2,597	1,174	3,381	5,687	1,136	1,876	742	4,173	1,011	1,876	755	0.96	93.94
7/22	0		1,948	1,214	2,565	5,002	695	954	728	1,375	2,313	3,217	290	0.72	94.66
7/23	0		1,298	1,413	62	4,338	752	561	913	1,371	2,872	1,973		0.64	95.30
7/24	0		2,597	1,488	184	1,403	1,178	690	1,258	1,322	2,703	471		0.57	95.87
7/25	0		2,597	1,839	169	358	661	513	1,985	891	2,641	67		0.53	96.40
7/26	0		2,597	1,989	143	219	161	564	797	510	2,495	68		0.44	96.85
7/27	0		2,597	1,974	117	160	354	480	723	317	2,265	73		0.43	97.28
7/28	0		1,948	2,109	74	71	120	341	691	375	4,130	256		0.45	97.72
7/29	0		649	2,146	159	20	0	259	525	249	601	978		0.30	98.03
7/30	0		649	1,377	239	11	922	303	1,054	483	525	376		0.30	98.33
7/31	0		649	957	663	18	305	180	1,602	1,279	318	153		0.27	98.60
8/01	0		0	660	0	18	0	190	1,102	375	447	161		0.15	98.74
8/02	0		3,246	790	0	12	0	174	489	126	46	334		0.24	98.99
8/03	0		0	734	0	16	0	142	436	0	269	149		0.10	99.09
8/04	0		0	658	258	43	641	161	156	0	557	123		0.13	99.22
8/05	0		0	73	0	122	310	478	205	0	828	79		0.09	99.31
8/06	0		0	118	0	174	155	686	170	0	3,290	159		0.17	99.48
8/07			0	110	0	110	80	260	248	0	1,863	92		0.11	99.59
8/08			0	281	0	472	65	101	945	62	5,102	48		0.26	99.86
8/09			0	309	0	445	62	45	175	568	896	61		0.11	99.96
8/10			0	0	0	172	141	47	0	549	0	70		0.04	100.00
8/11			0	0	0	206	58	31	0	136	0	82			
8/12			0	0	0	487	0	19	0	0	0	122			
8/13			0	0	0	260	0	21	0	0	297	114			
8/14			0	0	0	511	0	23	0	0	199	166			
8/15			0	0	0	231	0	38	0	0	47	177			
8/16			0	0	0	145	0	37	0	0	16	32			
8/17			0	0	0	71	0	30	0	0	97	13			
8/18			0		0	54			0	0	97	25			
8/19					0	54			0	0	68	12			

-Continued-

Table 17. (p 3 of 3)

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Average Proportion[a]	
														Daily	Cumulative
8/20					0	41			0	0	0	13			
8/21					0	9			0	0	0	4			
8/22					0				0	0	0				
8/23					0				0	0	0				
8/24					0					0	0				
8/25					0					0	0				
Total	331,678	143,324	230,141	106,279	362,369	214,481	168,276	147,430	186,418	377,512	329,793	287,280	302,678		

[a] Average proportions for 1980 - 1992, June 4 through August 10.

Table 18. Age, sex, and size composition of chum salmon
          escapement, Nushagak River sonar project, 1992.

	Age Group			
	0.3	0.4	0.5	Total
Sample Period 1:	9 June - 3 July			
Males	41,368	64,090		105,458
Percent	19.35	29.97		49.32
Sample Si╴╴	71	110		181
Mean Leng╴╴	579	593		588
Std. Error	3	3		2
Sample Size	70	109		179
Females	47,777	60,595		108,372
Percent	22.34	28.34		50.68
Sample Size	82	104		186
Mean Length	540	556		549
Std. Error	3	2		2
Sample Size	82	104		186
Both Sexes	89,145	124,685		213,830
Percent	41.69	58.31		100.00
Sample Size	153	214		367
Mean Length	558	575		568
Std. Error	2	2		1
Sample Size	152	213		365

-Continued-

Table 18. (p 2 of 3).

	Age Group			
	0.3	0.4	0.5	Total

Sample Period 2: 4 - 22 July

Males	23,566	20,381	318	44,265
Percent	26.52	22.94	0.36	49.82
Sample Size	74	64	1	139
Mean Length	585	603	620	594
Std. Error	3	4		3
Sample Size	73	64	1	138
Females	23,565	21,018		44,583
Percent	26.52	23.66		50.18
Sample Size	74	66		140
Mean Length	541	559		549
Std. Error	3	4		2
Sample Size	73	65		138
Both Sexes	47,131	41,399	318	88,848
Percent	53.05	46.60	0.36	100.00
Sample Size	148	130	1	279
Mean Length	563	581	620	572
Std. Error	2	3		2
Sample Size	146	129	1	276

-Continued-

Table 18. (p 3 of 3).

	Age Group			
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	0.3	0.4	0.5	Total

All Periods Combined:

	0.3	0.4	0.5	Total
Males	64,934	84,471	318	149,723
Percent	21.45	27.91	0.11	49.47
Sample Size	145	174	1	320
Mean Length	581	596	620	590
Std. Error	2	2		2
Sample Size	143	173	1	317
Females	71,342	81,613		152,955
Percent	23.57	26.96		50.53
Sample Size	156	170		326
Mean Length	540	557		549
Std. Error	2	2		1
Sample Size	155	169		324
Both Sexes	136,276	166,084	318	302,678
Percent	45.02	54.87	0.11	100.00
Sample Size	301	344	1	646
Mean Length	560	577	620	569
Std. Error	2	1		1
Sample Size	298	342	1	641

Figure 1. Bristol Bay area with location of Nushagak River sonar project site.

249 m ——— X Right bank
sonar site

Flow

approx
365 m

Left bank
sonar site

X ——— 298 m ———

Inshore: 4.9 - 7.0 m

Offshore: 18.9 - 19.2 m

Tripod placement
and minimum and
maximum counting
ranges

249 meters

Surface

Left scale	Right scale
0	0
1 m	1 m
2 m	2 m
3 m	3 m
4 m	4 m
5 m	5 m
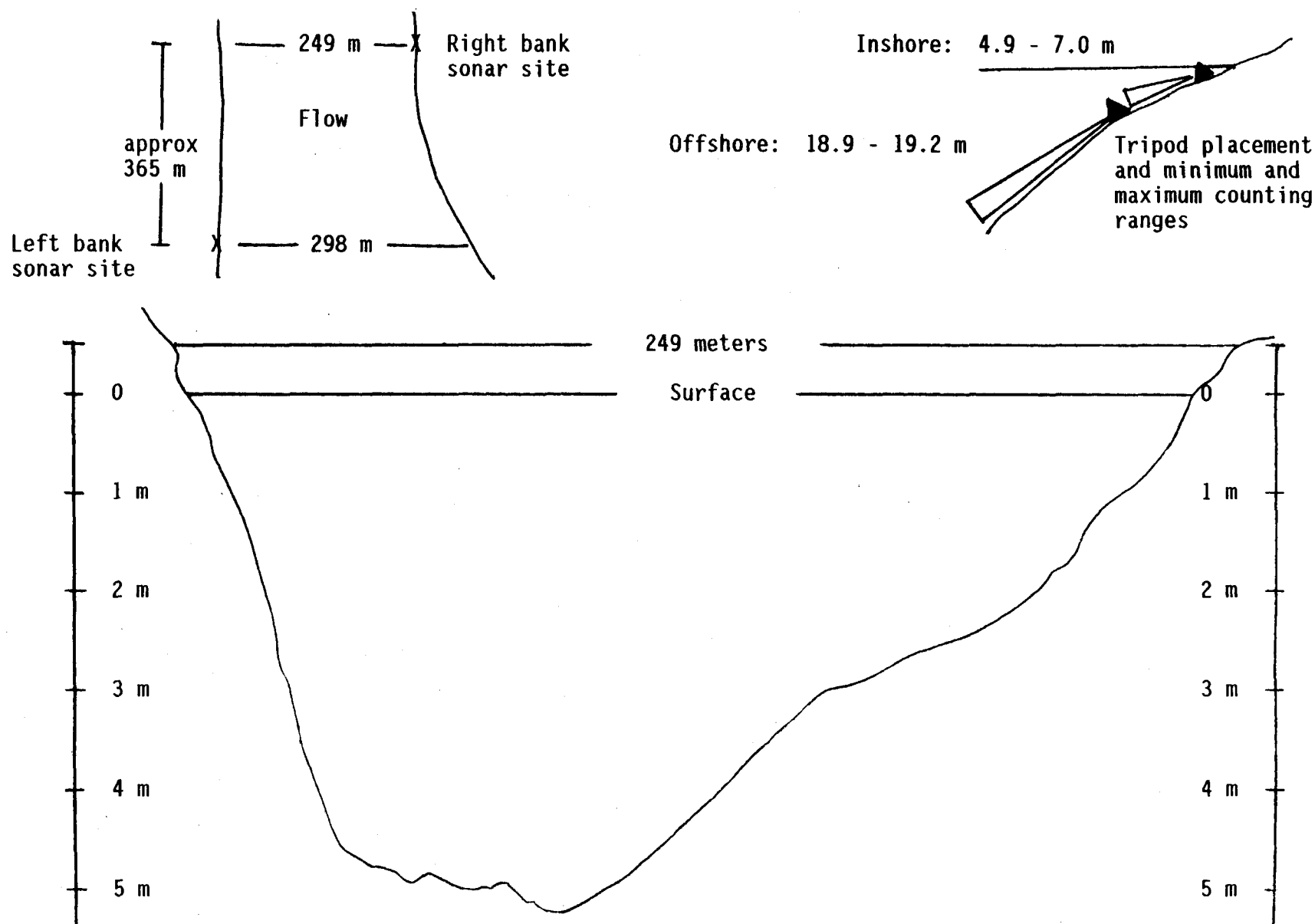
Figure 2. Detailed right bank sonar placement, relationship to left bank sonar, and bottom profile of Nushagak
River at right bank sonar site, 1992.

Inshore:
7.0 - 8.8 m

Offshore:
10.2 - 14.6 m

Tripod placement
and minimum and
maximum counting
ranges

249 m ——X Right bank
sonar site

Flow

approx
365 m

Left bank
sonar site

X —— 298 m ——

298 meters

Surface

0

1 m

2 m

3 m

4 m

0

1 m

2 m

3 m

4 m

— 53 —
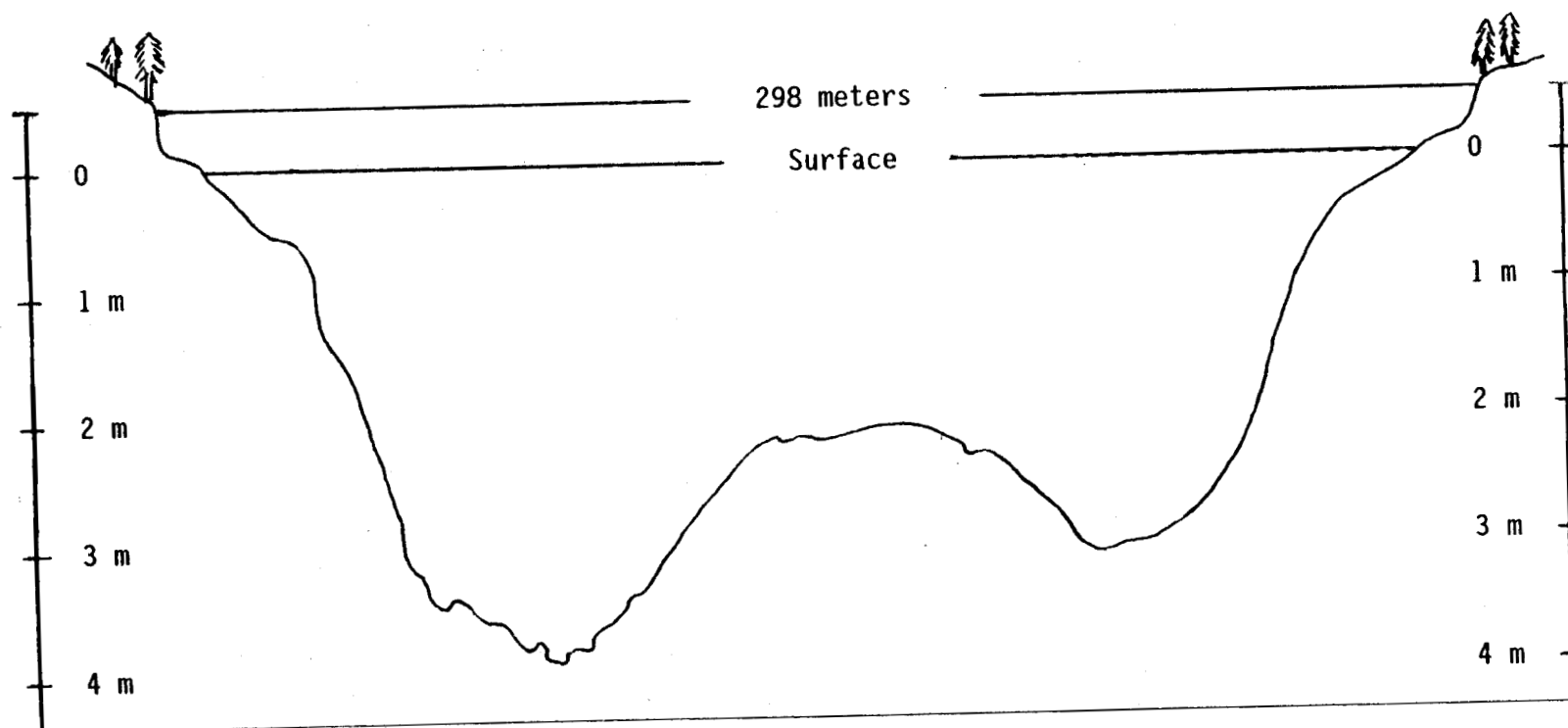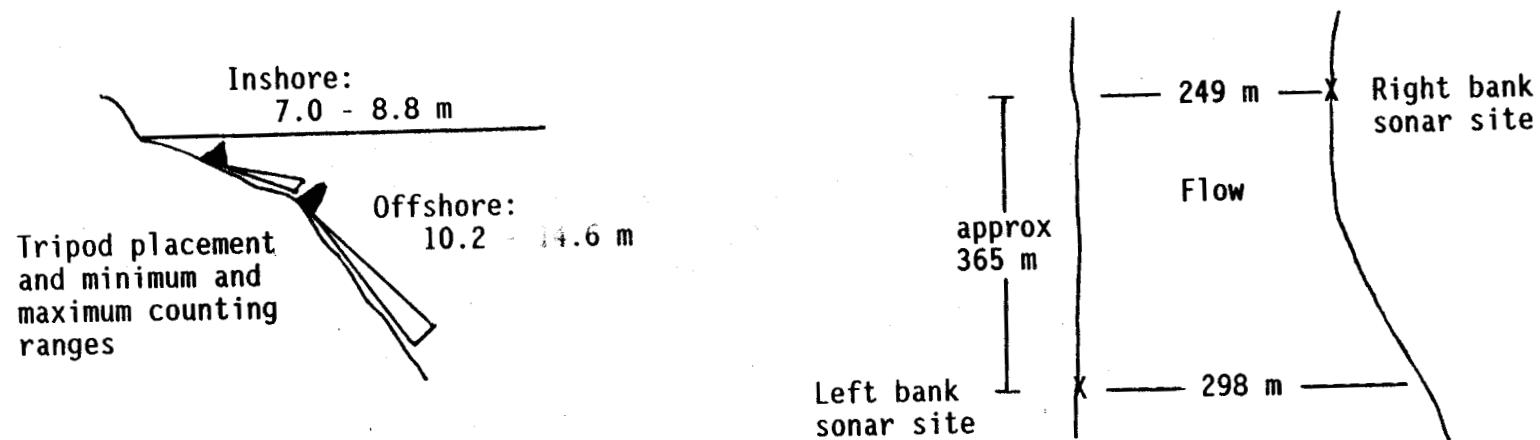
Figure 3. Detailed left bank sonar placement, relationship to right bank sonar, and bottom profile of Nushagak
River at left bank sonar site, 1992.
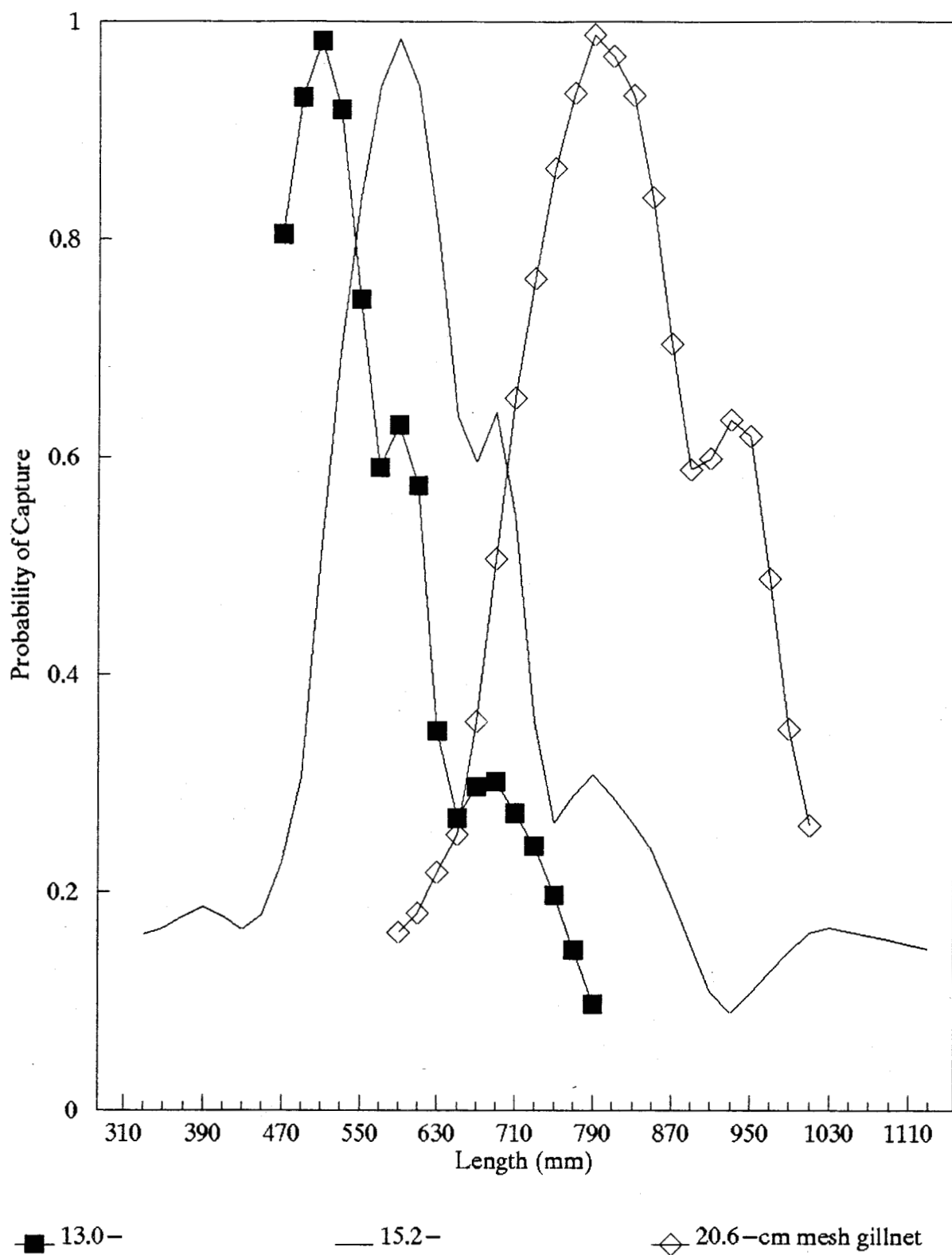
Figure 4. Chinook salmon gillnet selectivity curves for the mesh sizes used at the Nushagak River sonar project, 1992.
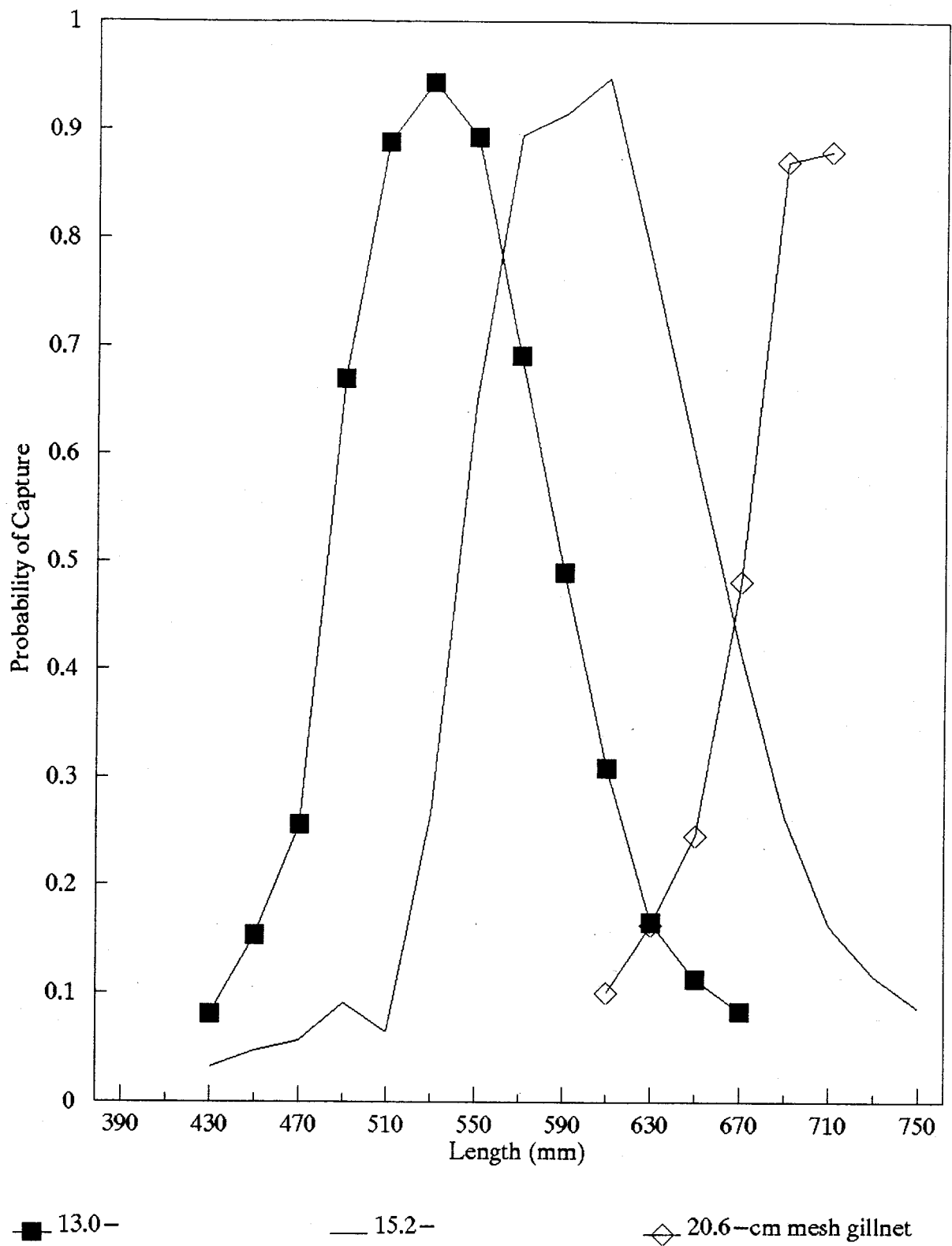
Figure 5. Chum salmon gillnet selectivity curves for the mesh sizes used at the Nushagak River sonar project, 1992.
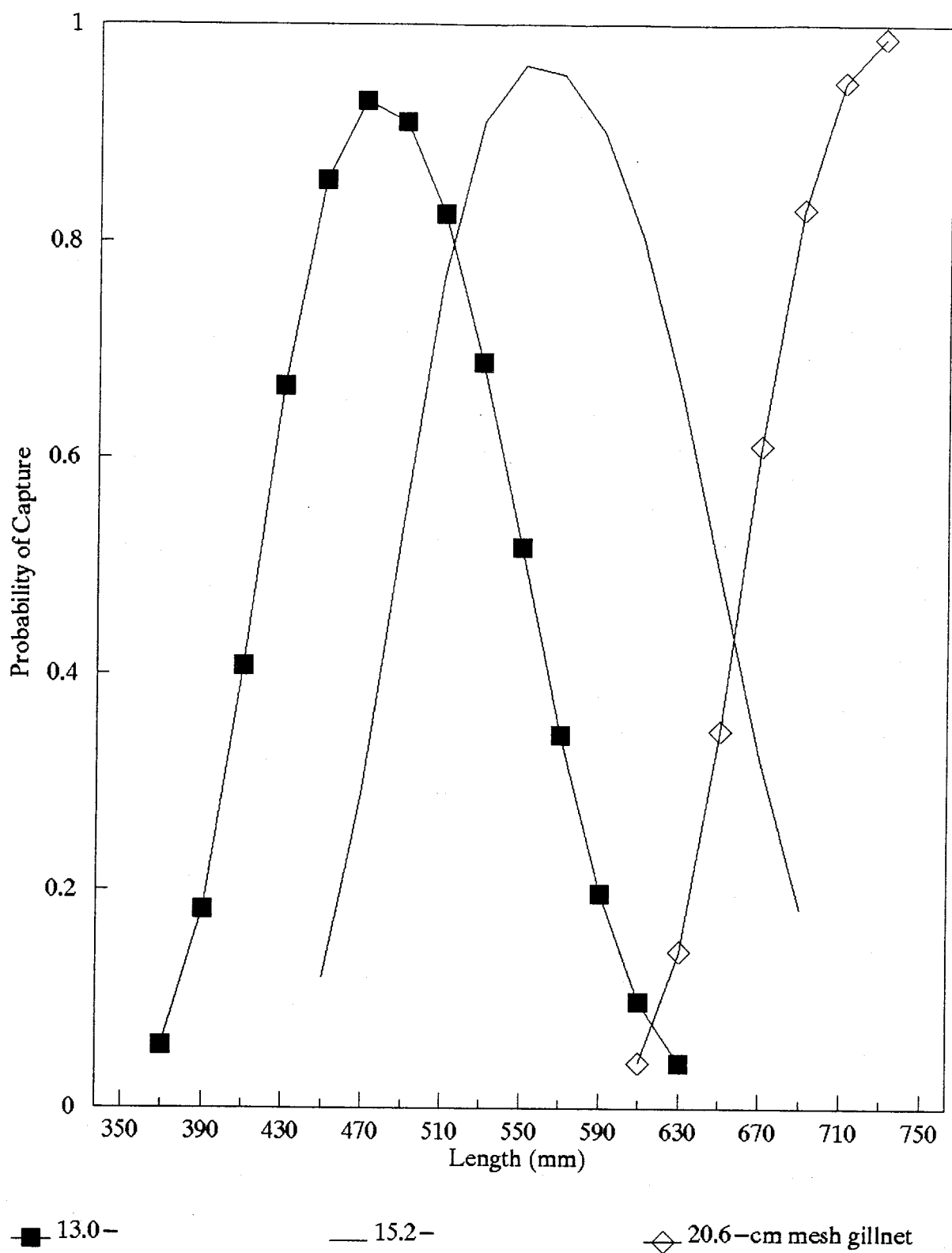
Figure 6. Sockeye salmon gillnet selectivity curves for the mesh sizes used at the Nushagak
River sonar project, 1992.

Right Bank — Inshore
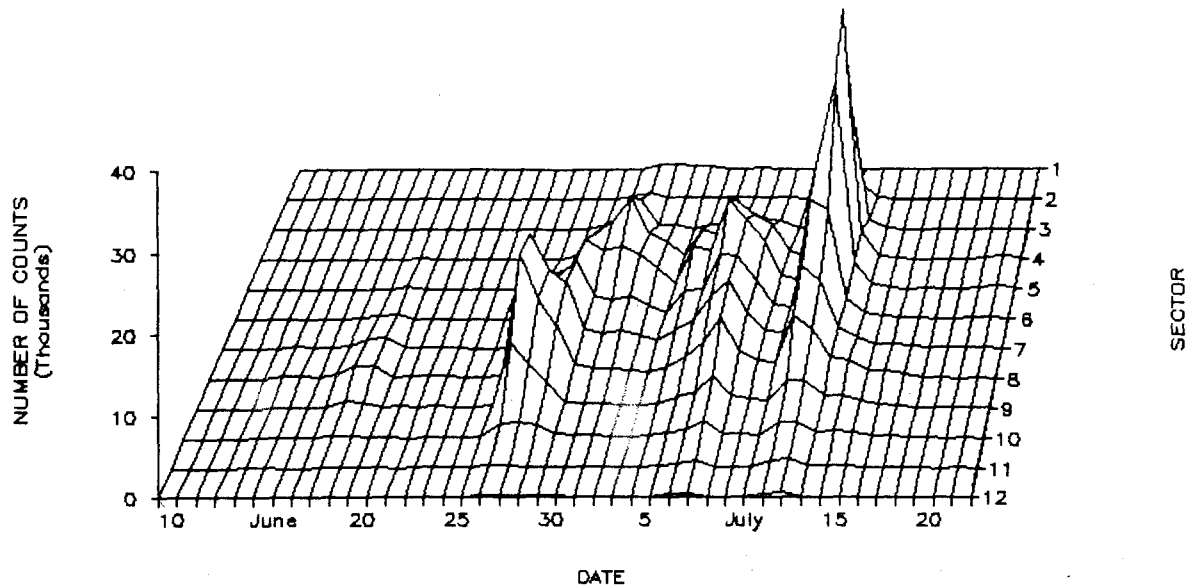
Right Bank — Offshore
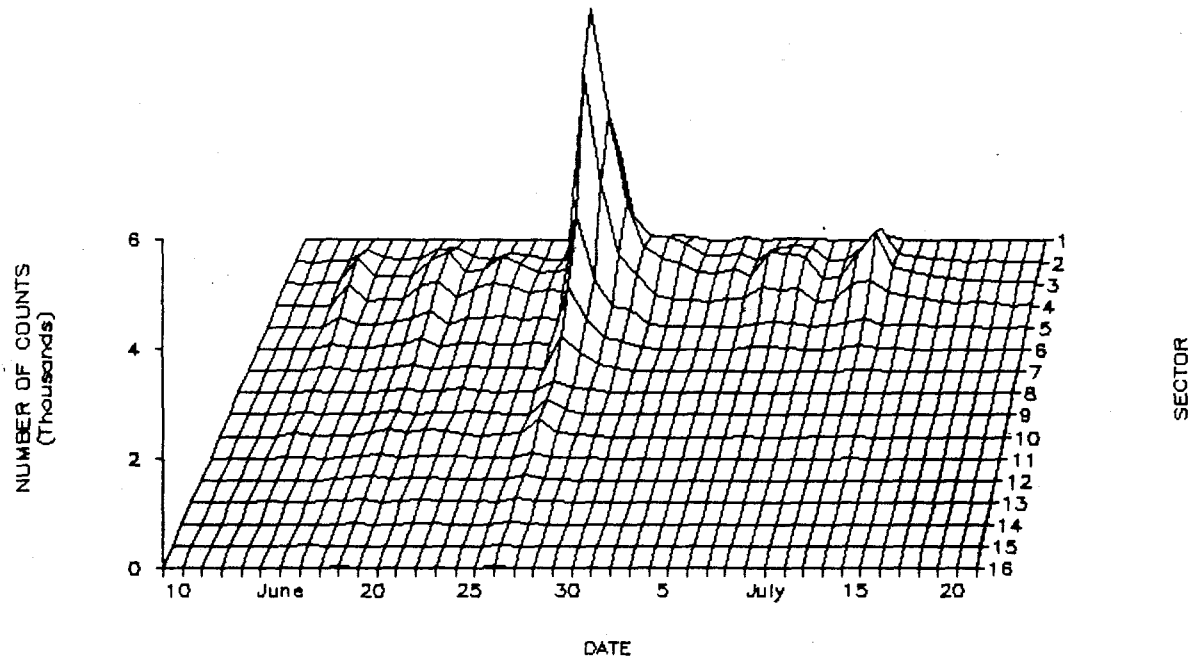
Figure 7. Number of sonar counts by sector for the right bank inshore and offshore counters, Nushagak River sonar project, 1992.

Left Bank — Inshore
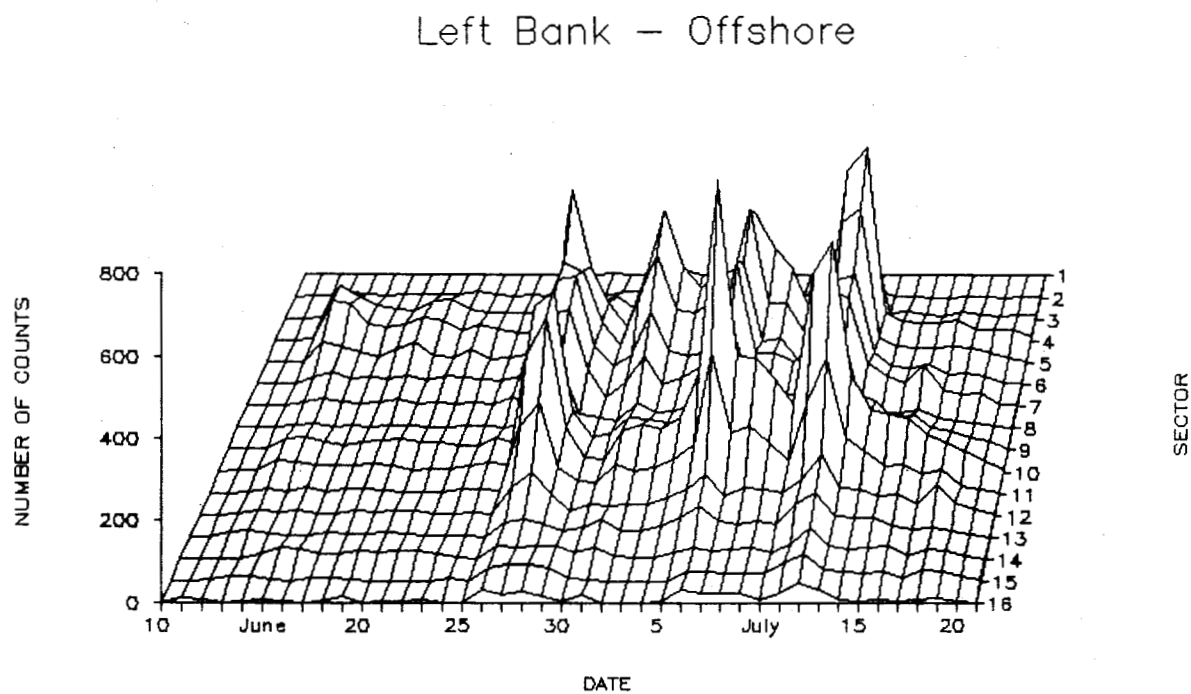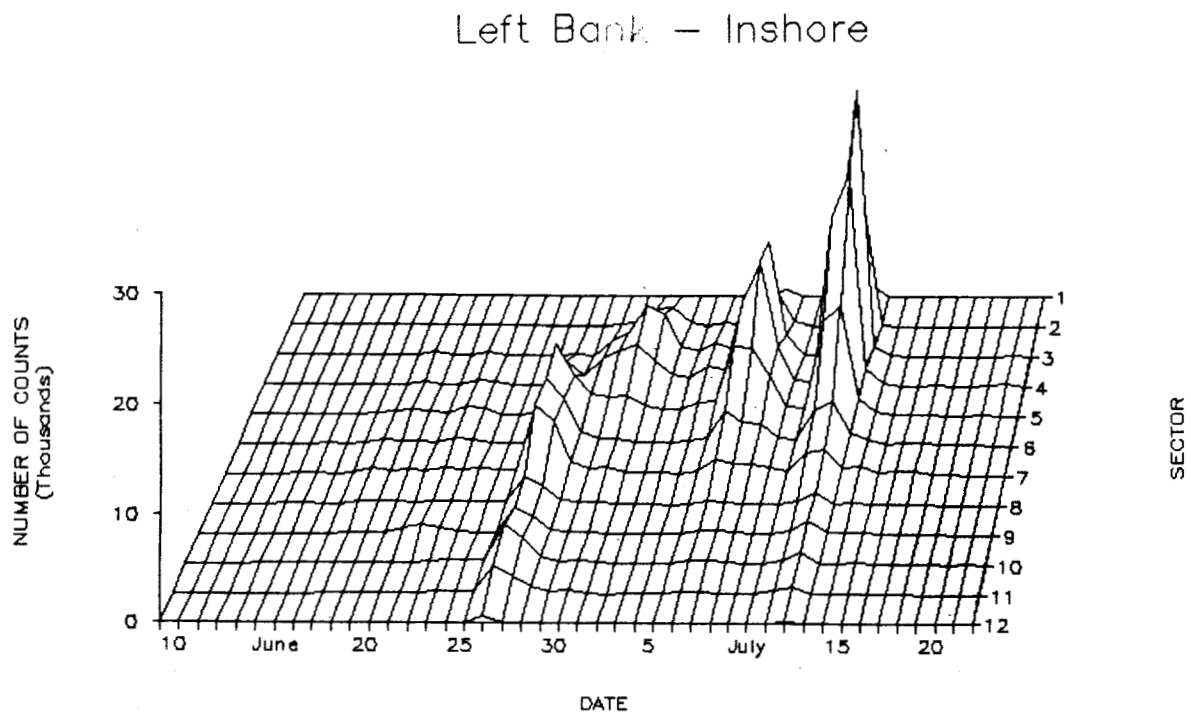
Left Bank — Offshore

Figure 8. Number of sonar counts by sector for the left bank inshore and offshore counters, Nushagak River sonar project, 1992.
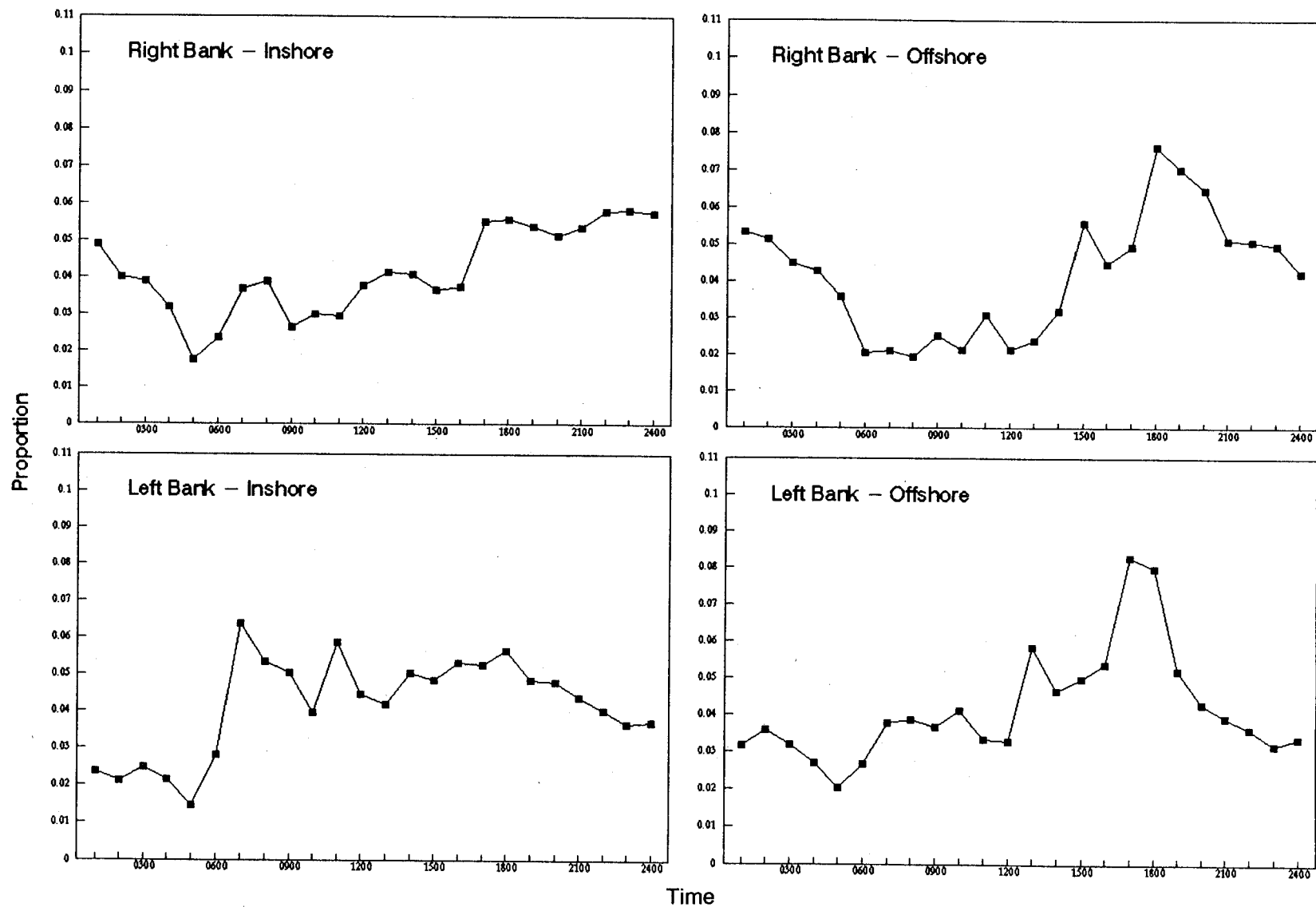
Figure 9. Proportion of sonar counts by hour for the right and left banks inshore and offshore counters, Nushagak River sonar project, 1992.
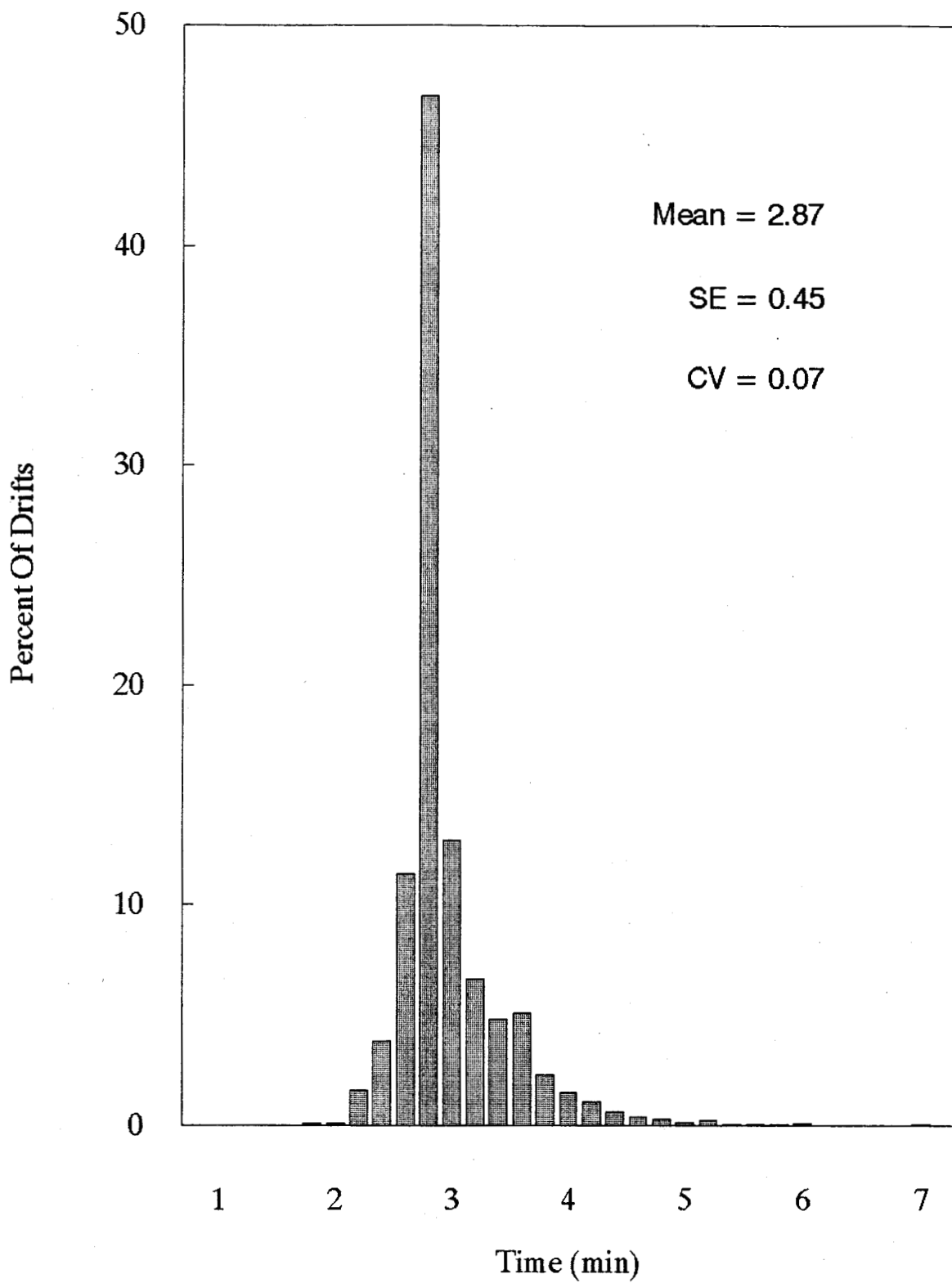
Figure 10. Distribution of mean fishing times for gillnet drifts conducted at the Nushagak River sonar project, 1992.
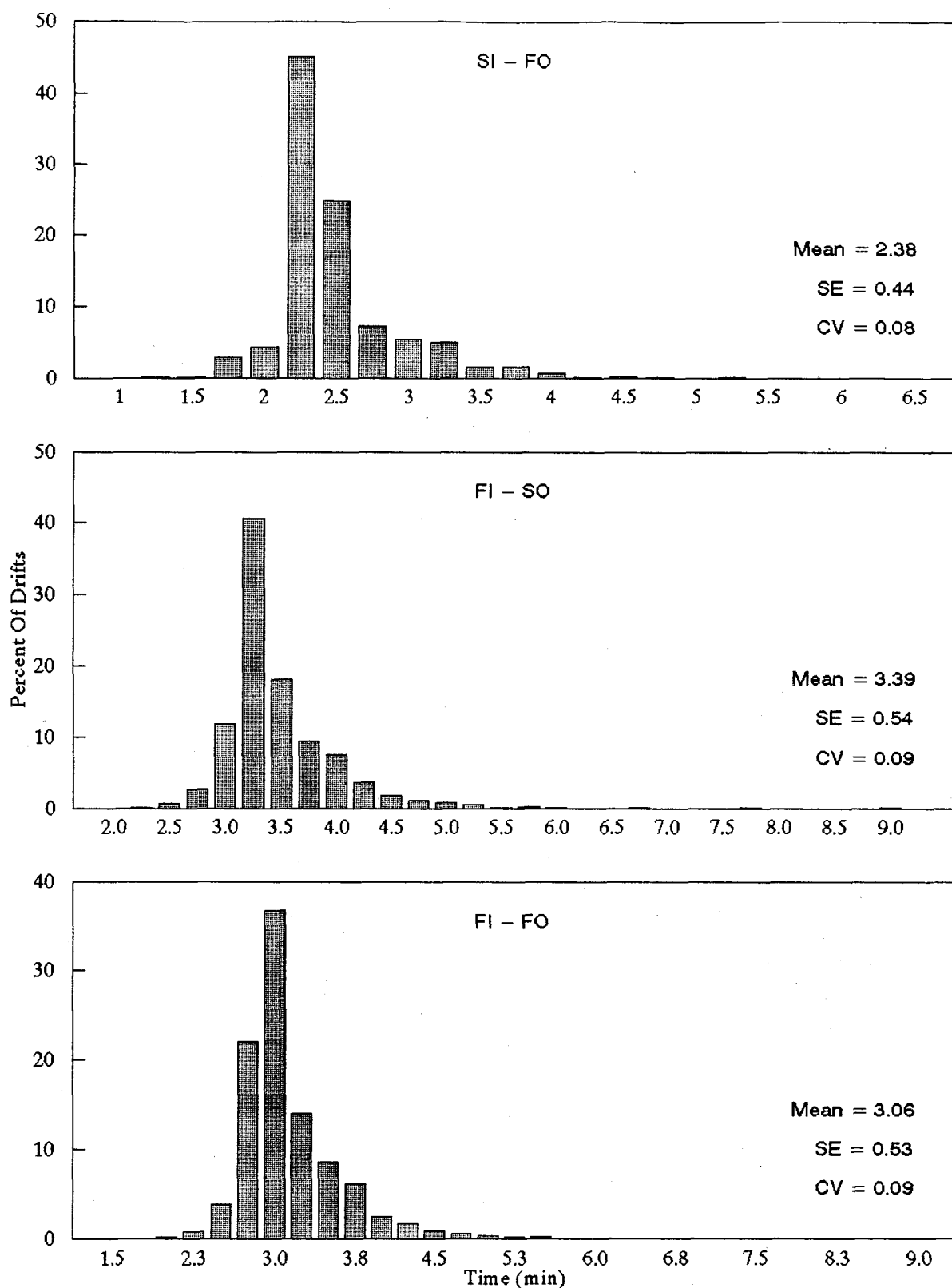
Figure 11. Distribution of alternatives to mean fishing time (MFT) for gillnet drifts conducted at the Nushagak River sonar project, 1992.
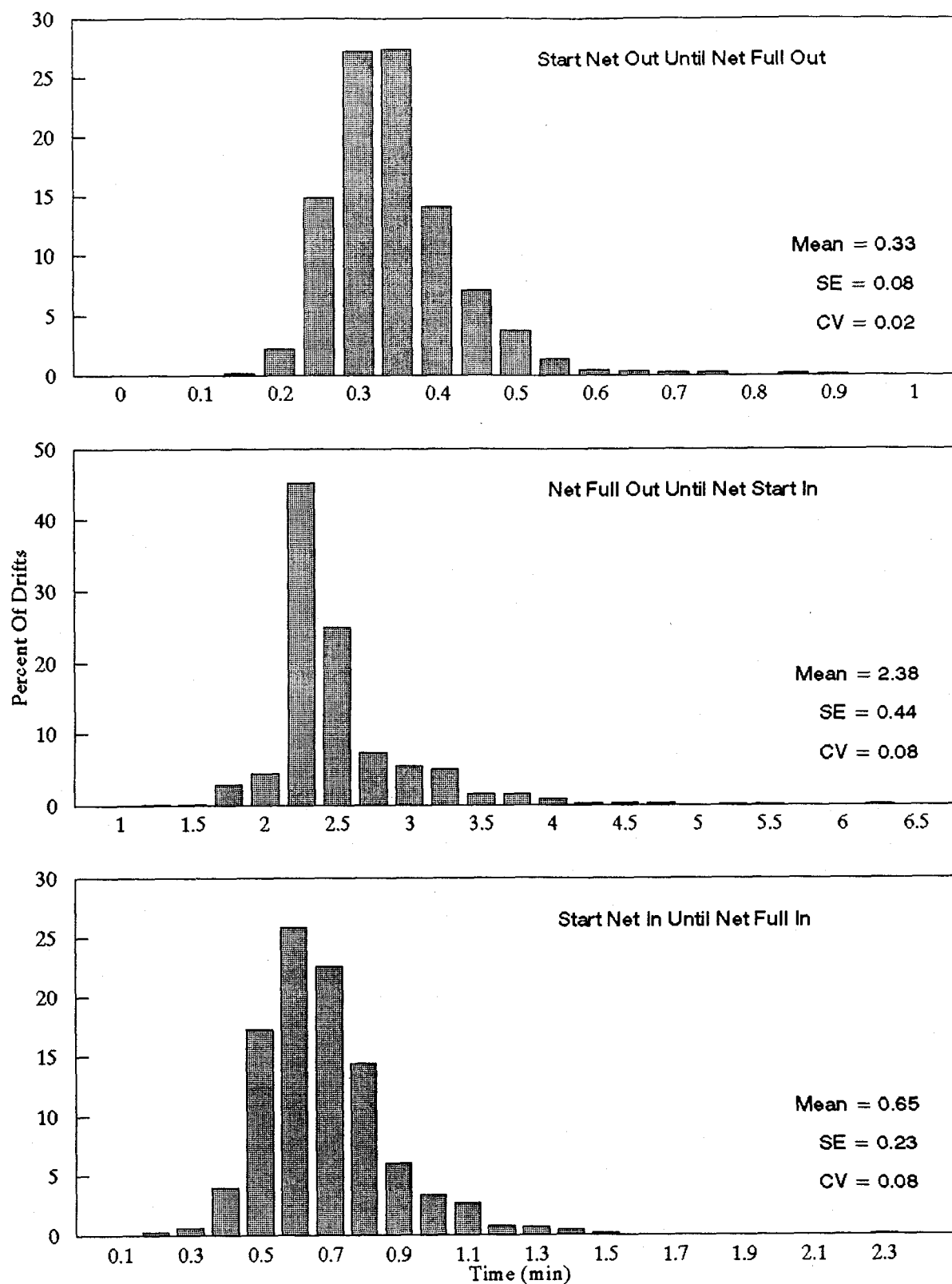
Figure 12. Distribution of the components of mean fishing time (MFT) for gillnet drifts conducted at the Nushagak River sonar project, 1992.
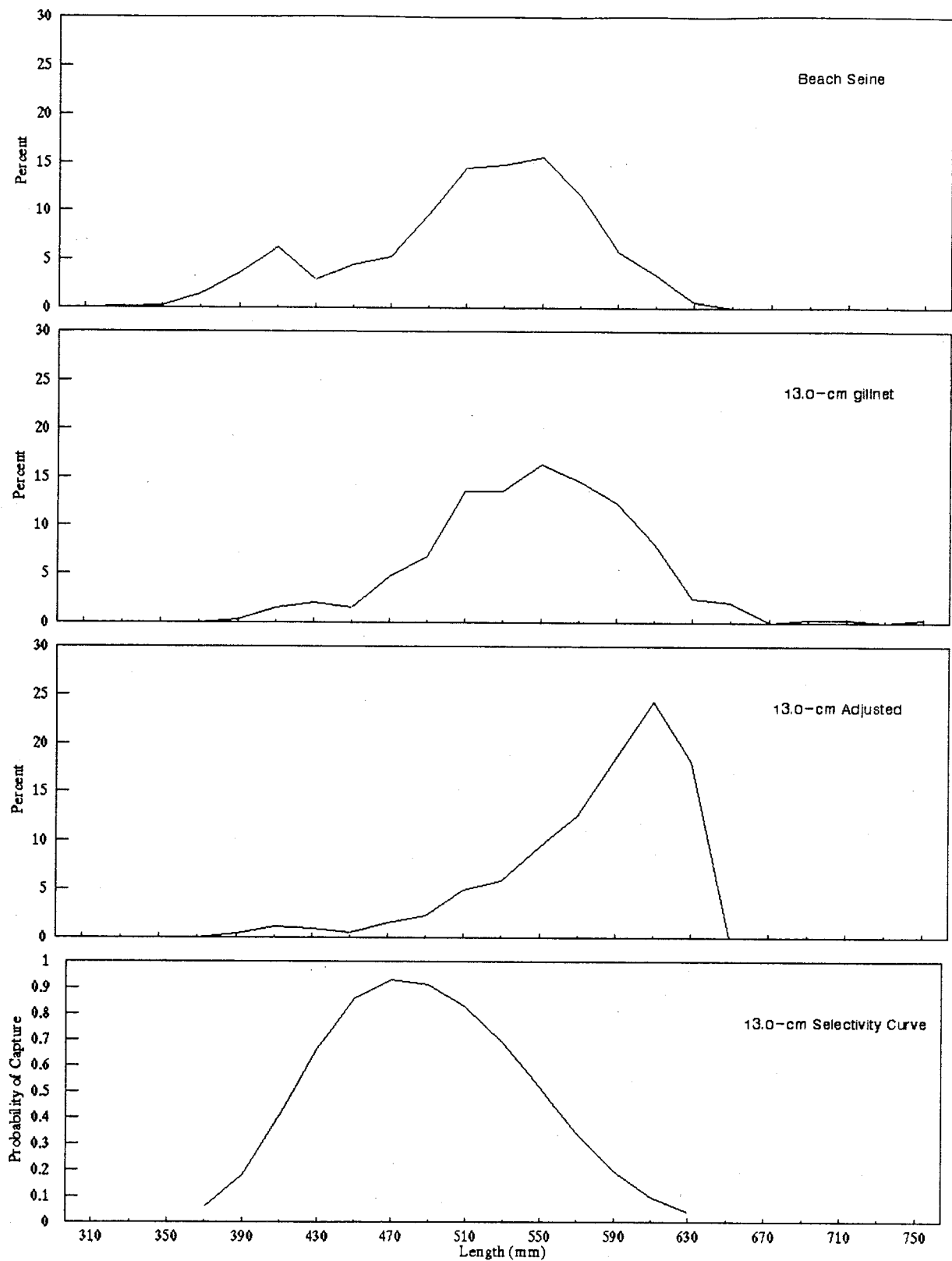
Figure 13. Length frequency distribution of sockeye salmon caught in a beach seine, 13.0-cm mesh gillnet, and 13.0-cm mesh adjusted for size selectivity, Nushagak River sonar project, 1992.
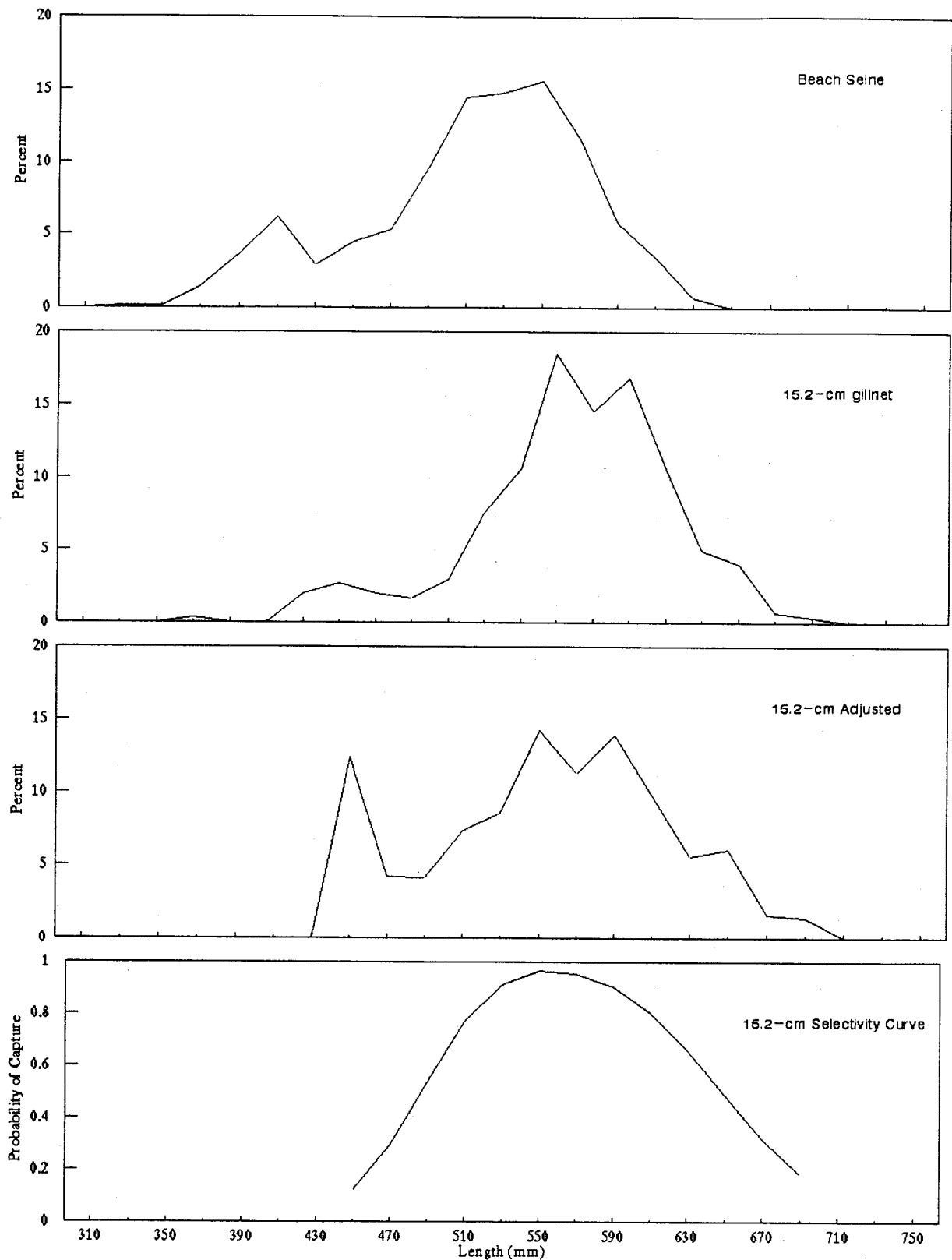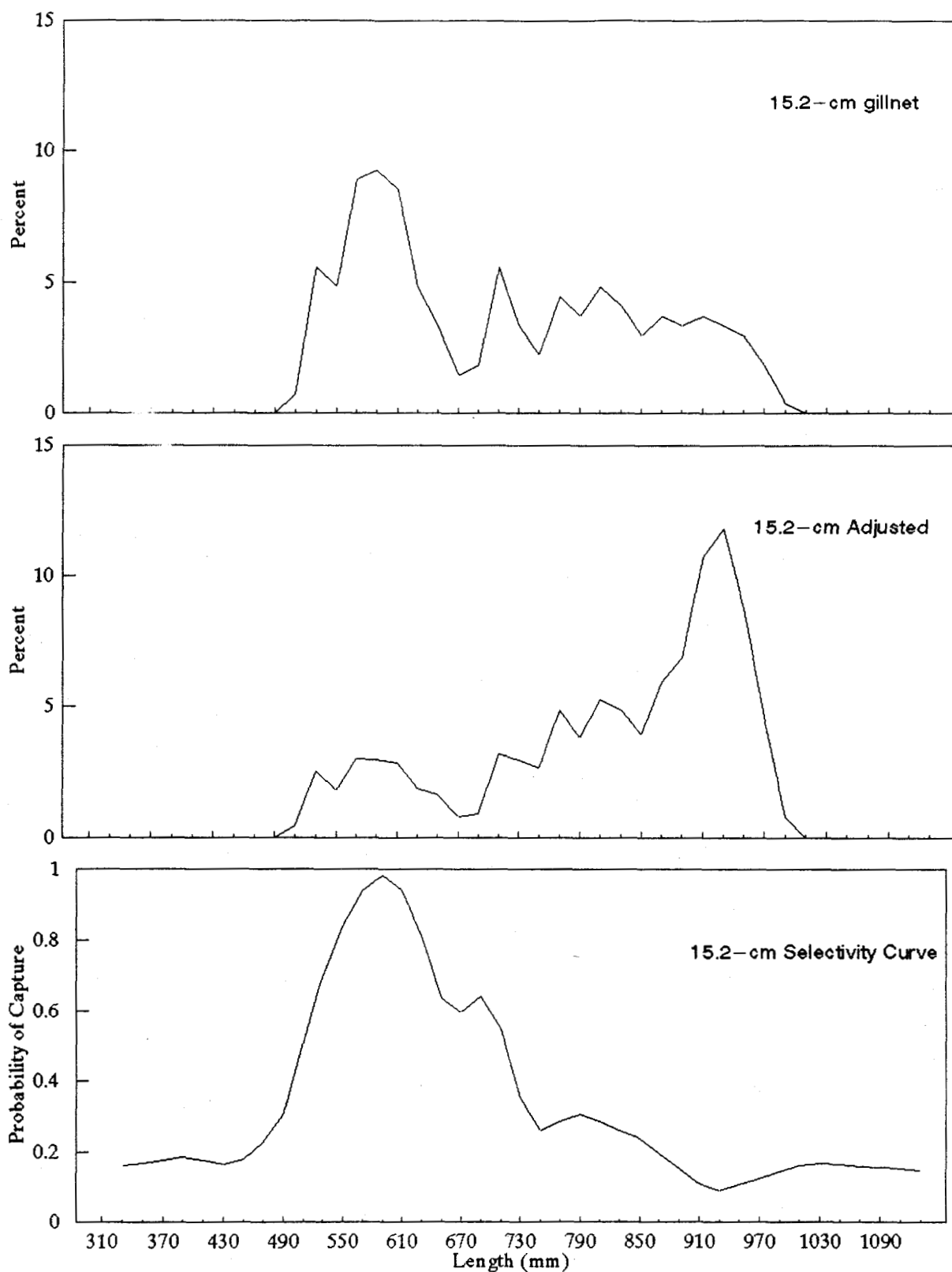
Figure 14. Length frequency distribution of sockeye salmon caught in a beach seine, 15.2-cm mesh gillnet, and 15.2-cm mesh adjusted for size selectivity, Nushagak River sonar project, 1992.
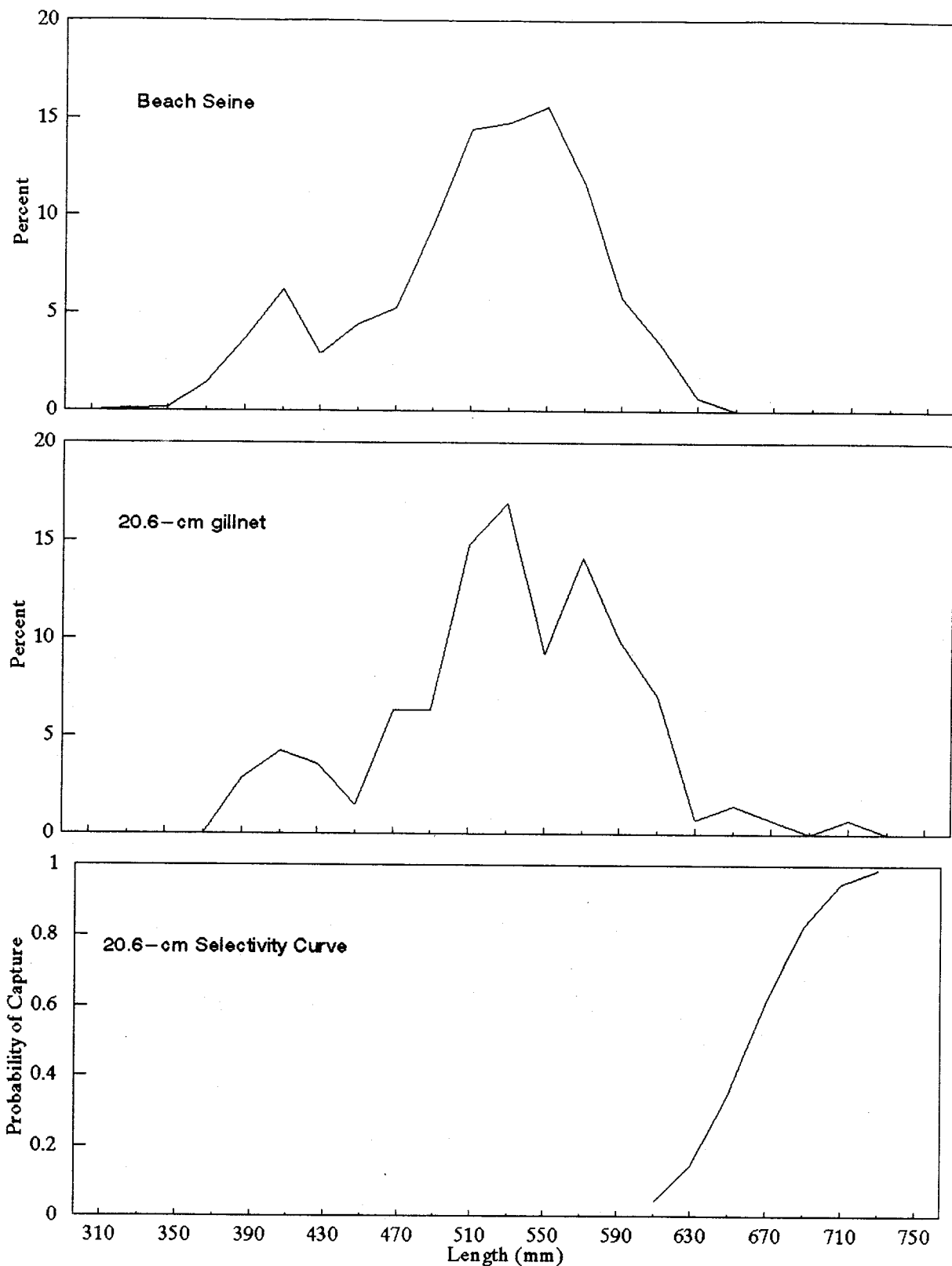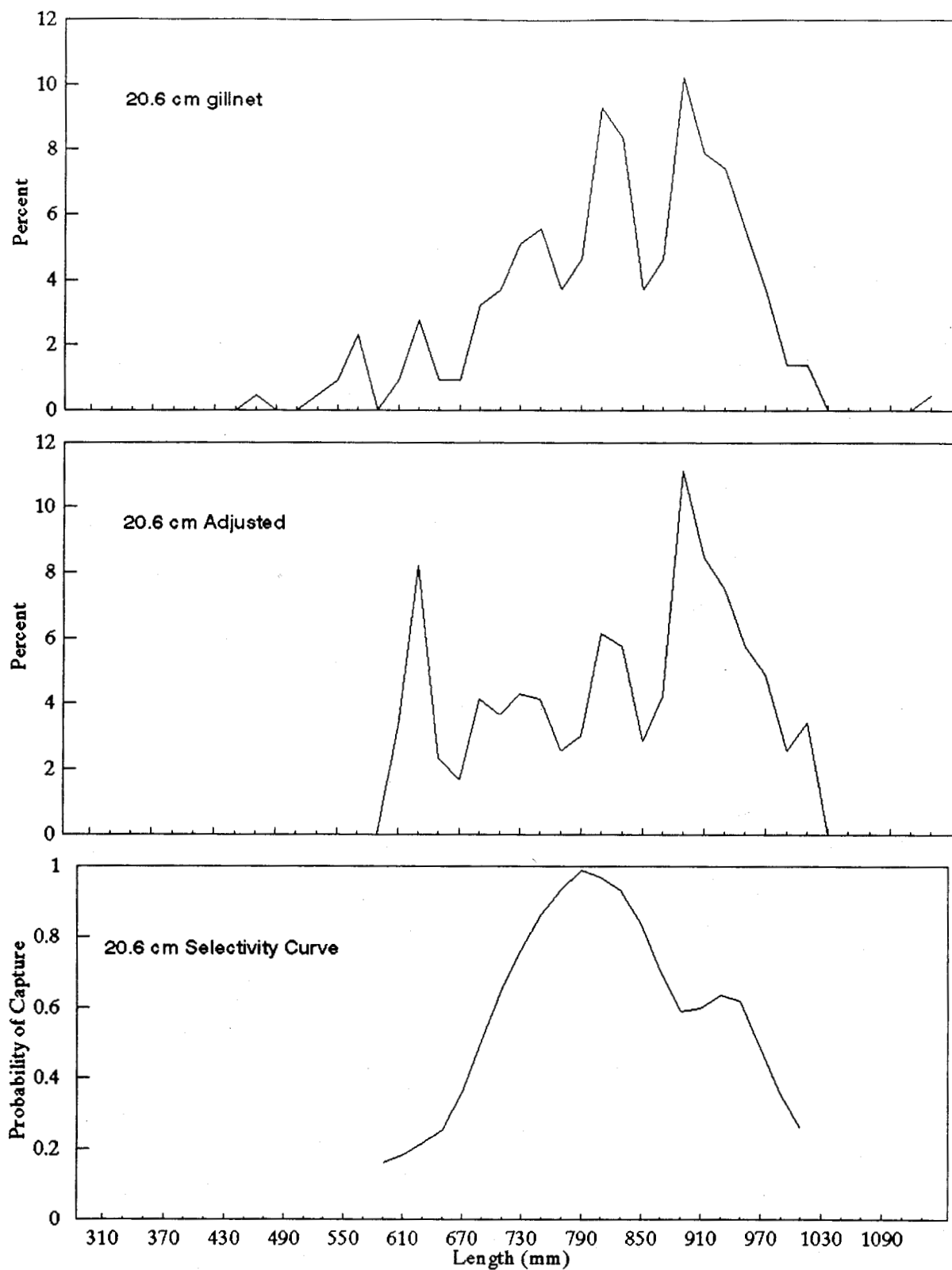
Figure 15. Length frequency distribution of sockeye salmon caught in a beach seine, 20.6-cm mesh gillnet, and 20.6-cm mesh adjusted for size selectivity, Nushagak River sonar project, 1992.
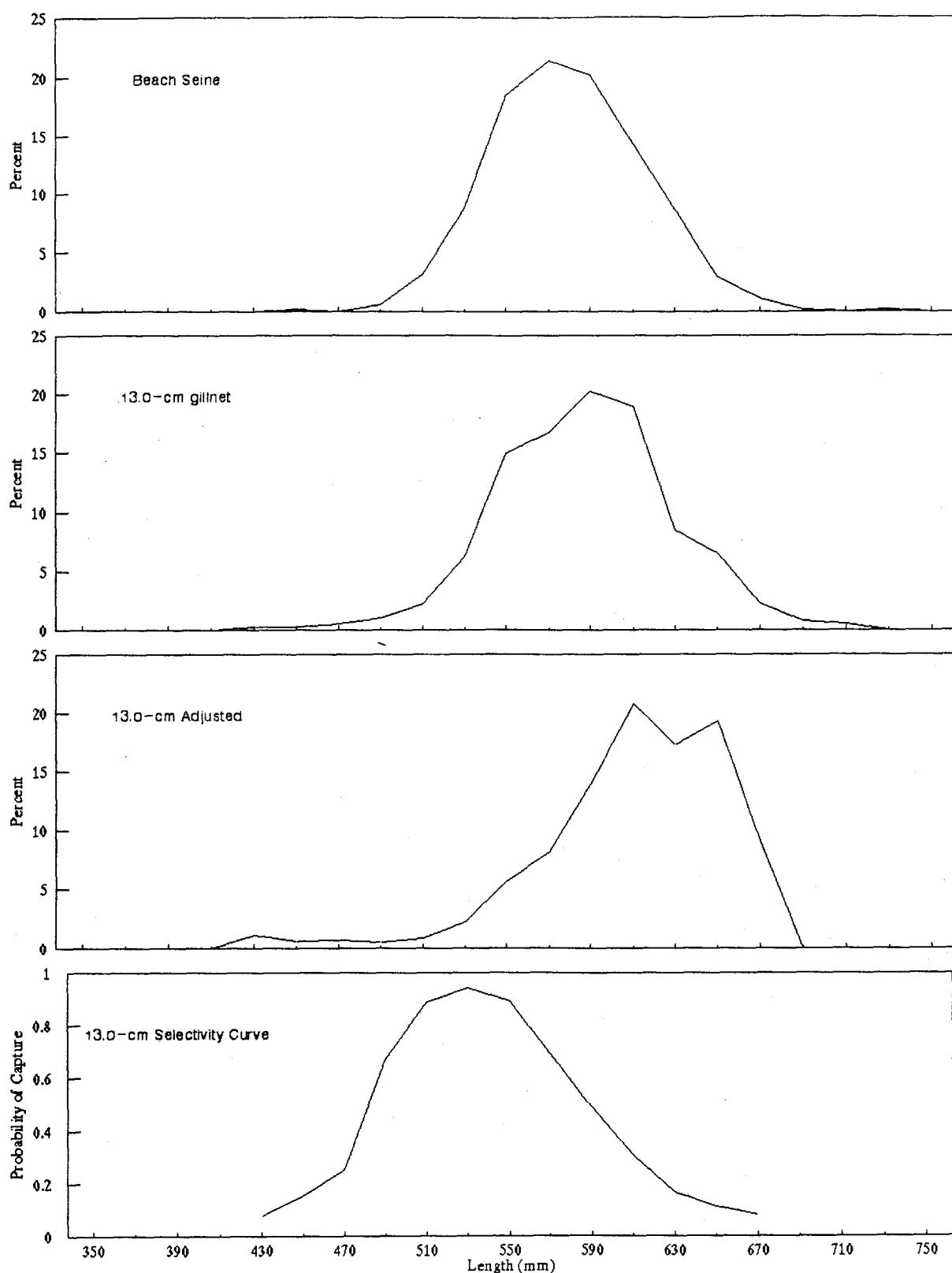
Figure 16. Length frequency distribution of chum salmon caught in a beach seine, 13.0-cm mesh gillnet, and 13.0-cm mesh adjusted for size selectivity, Nushagak River sonar project, 1992.
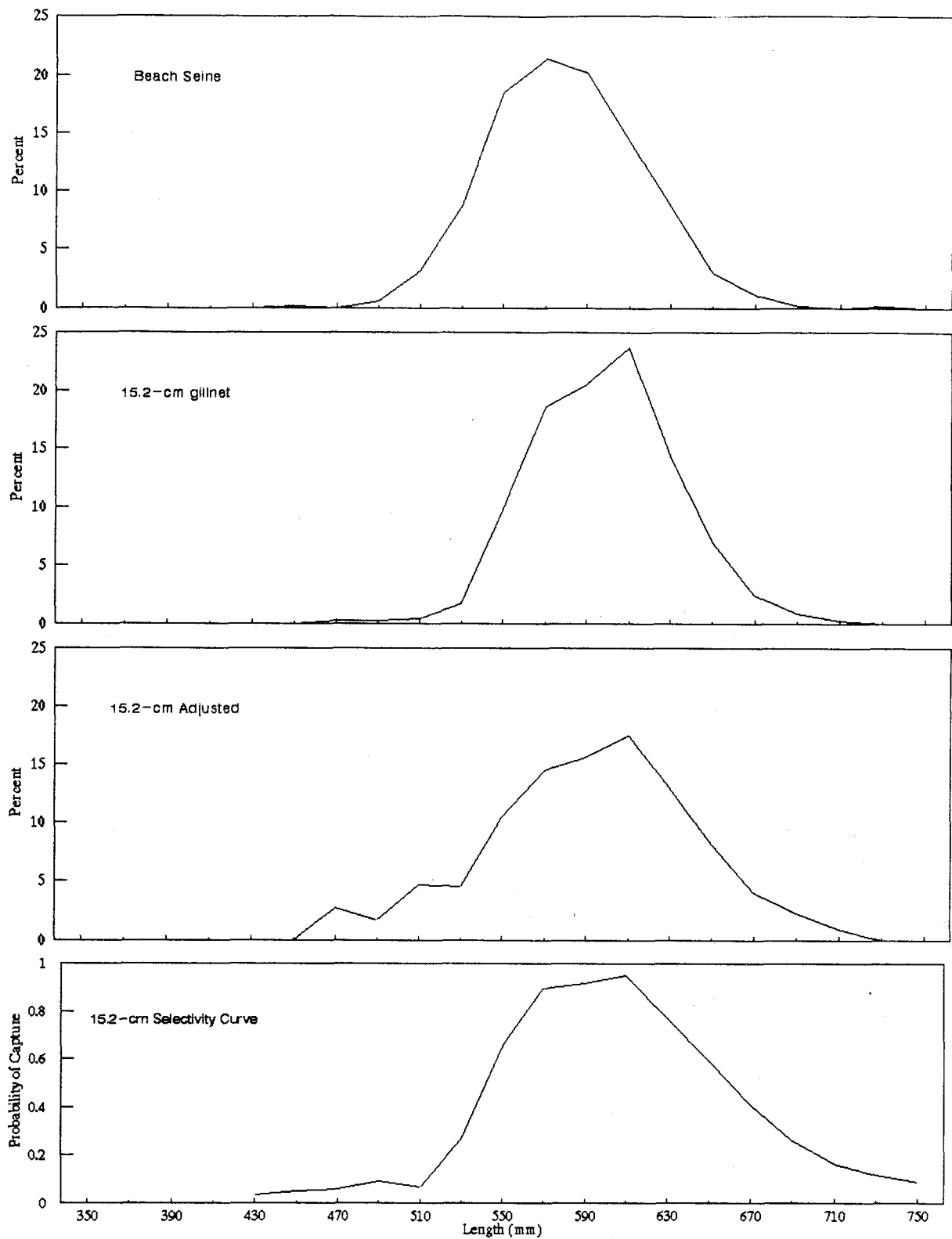
Figure 17. Length frequency distribution of chum salmon caught in a beach seine, 15.2-cm mesh gillnet, and 15.2-cm mesh adjusted for size selectivity, Nushagak River sonar project, 1992.
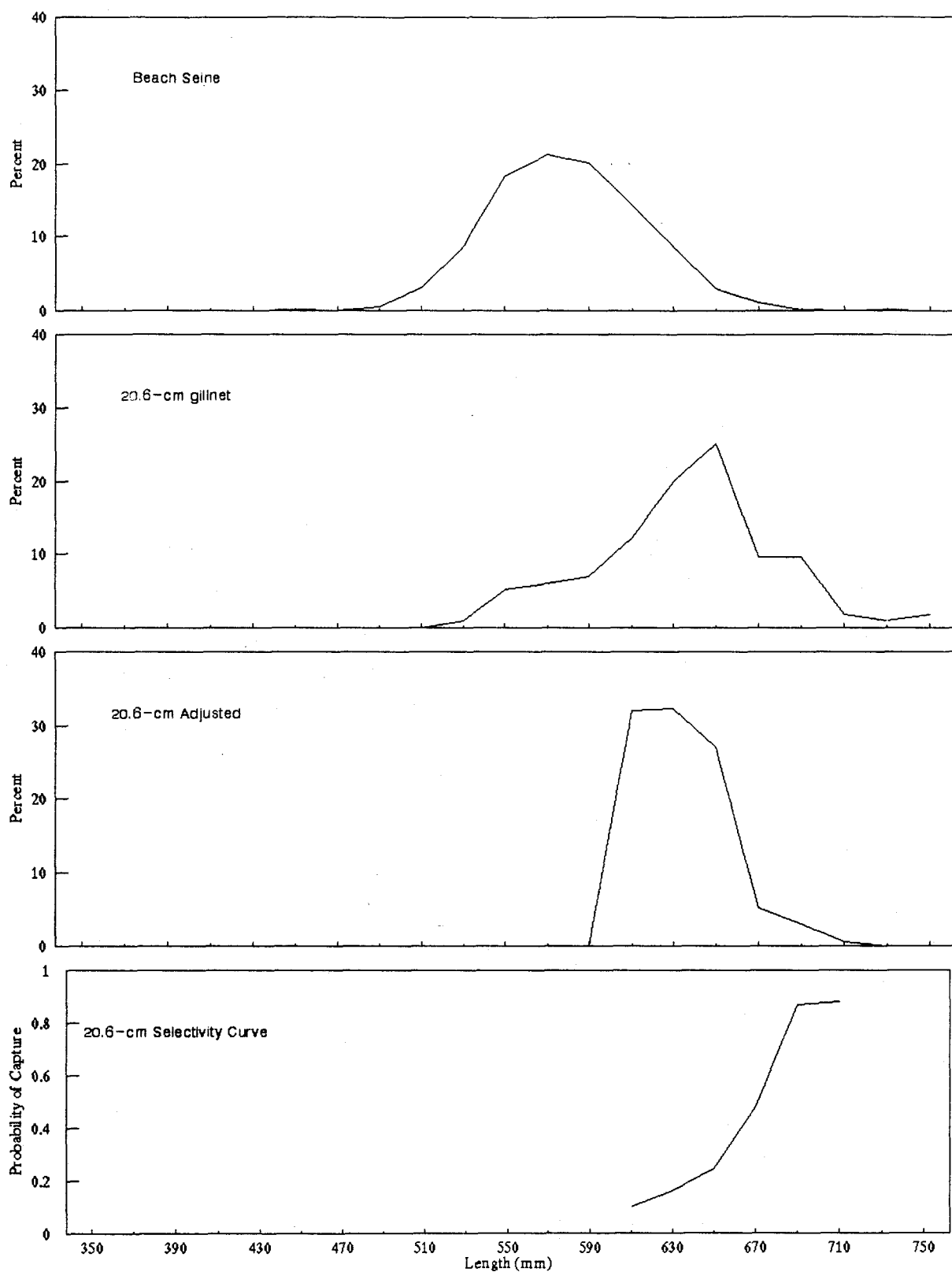
Figure 18. Length frequency distribution of chum salmon caught in a beach seine, 20.6-cm
mesh gillnet, and 20.6-cm mesh adjusted for size selectivity, Nushagak River
sonar project, 1992.
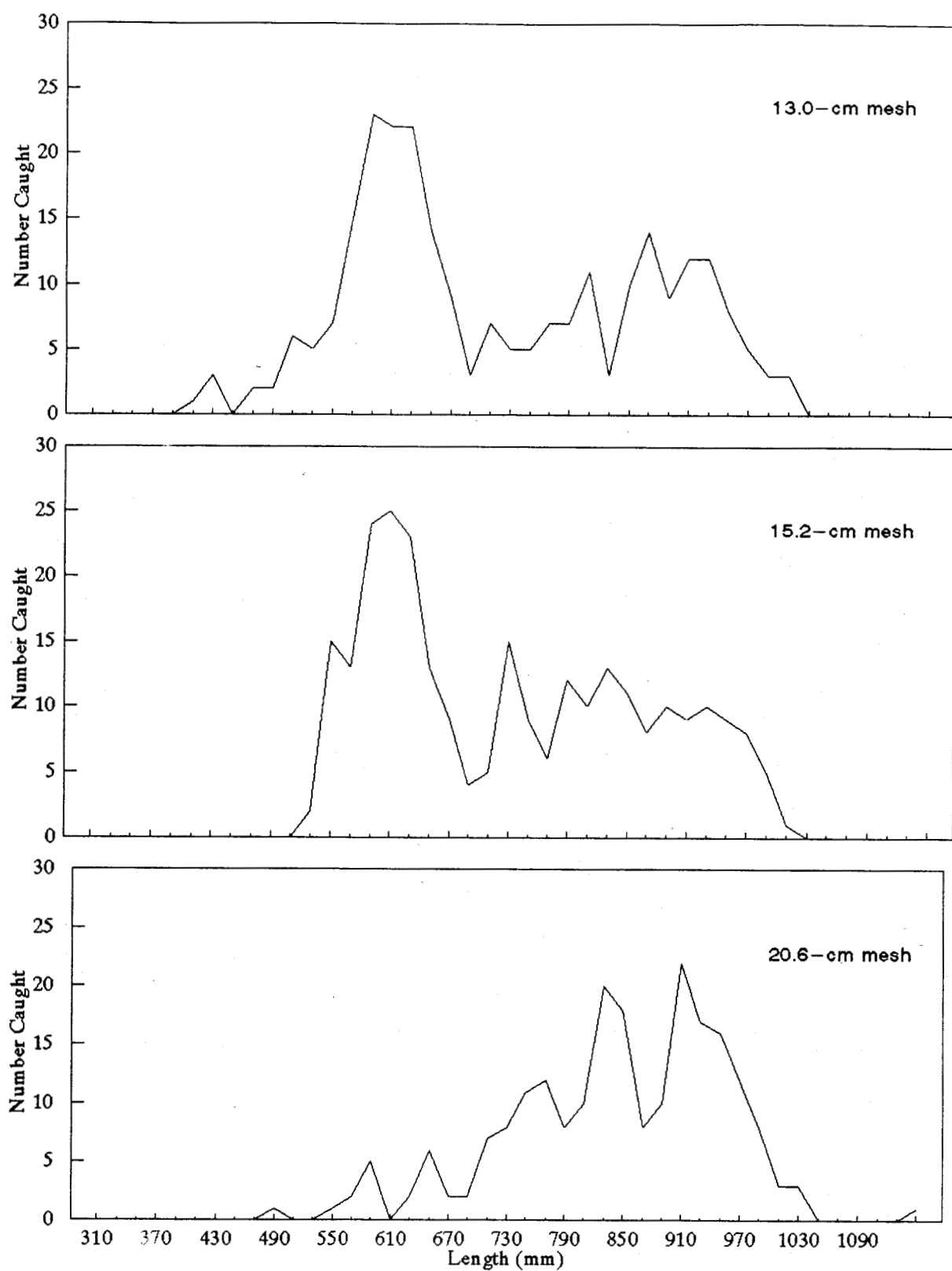
Figure 19. Number of chinook salmon caught in 13.0-, 15.2-, and 20.6-cm mesh gillnets, Nushagak River sonar project, 1992.
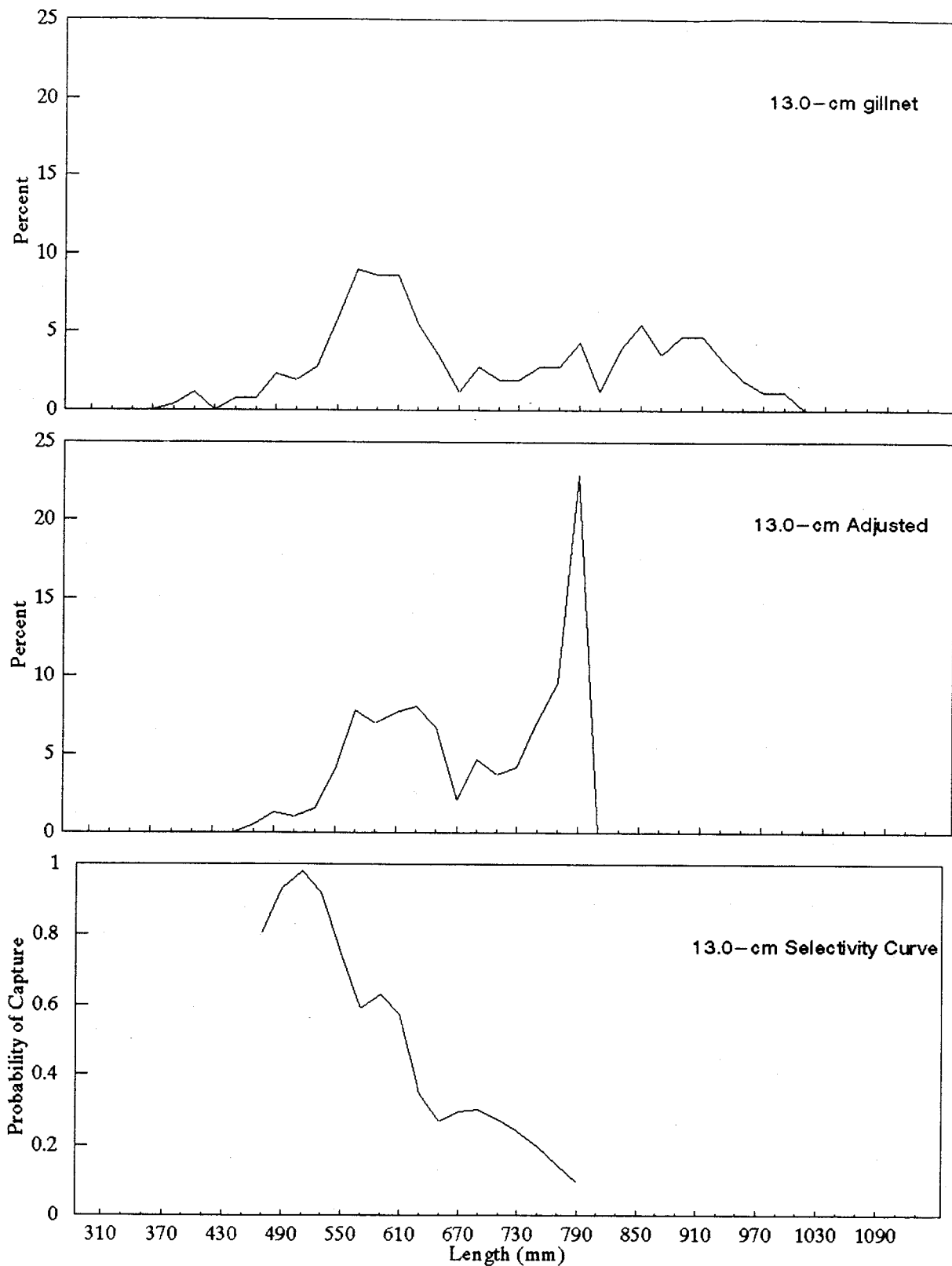
Figure 20. Length frequency distribution of chinook salmon caught in a 13.0-cm mesh gillnet and 13.0-cm mesh adjusted for size selectivity, Nushagak River sonar project, 1992.

Figure 21. Length frequency distribution of chinook salmon caught in a 15.2-cm mesh gillnet and 15.2-cm mesh adjusted for size selectivity, Nushagak River sonar project, 1992.

Figure 22. Length frequency distribution of chinook salmon caught in a 20.6-cm mesh gillnet and 20.6-cm mesh adjusted for size selectivity, Nushagak River sonar project, 1992.
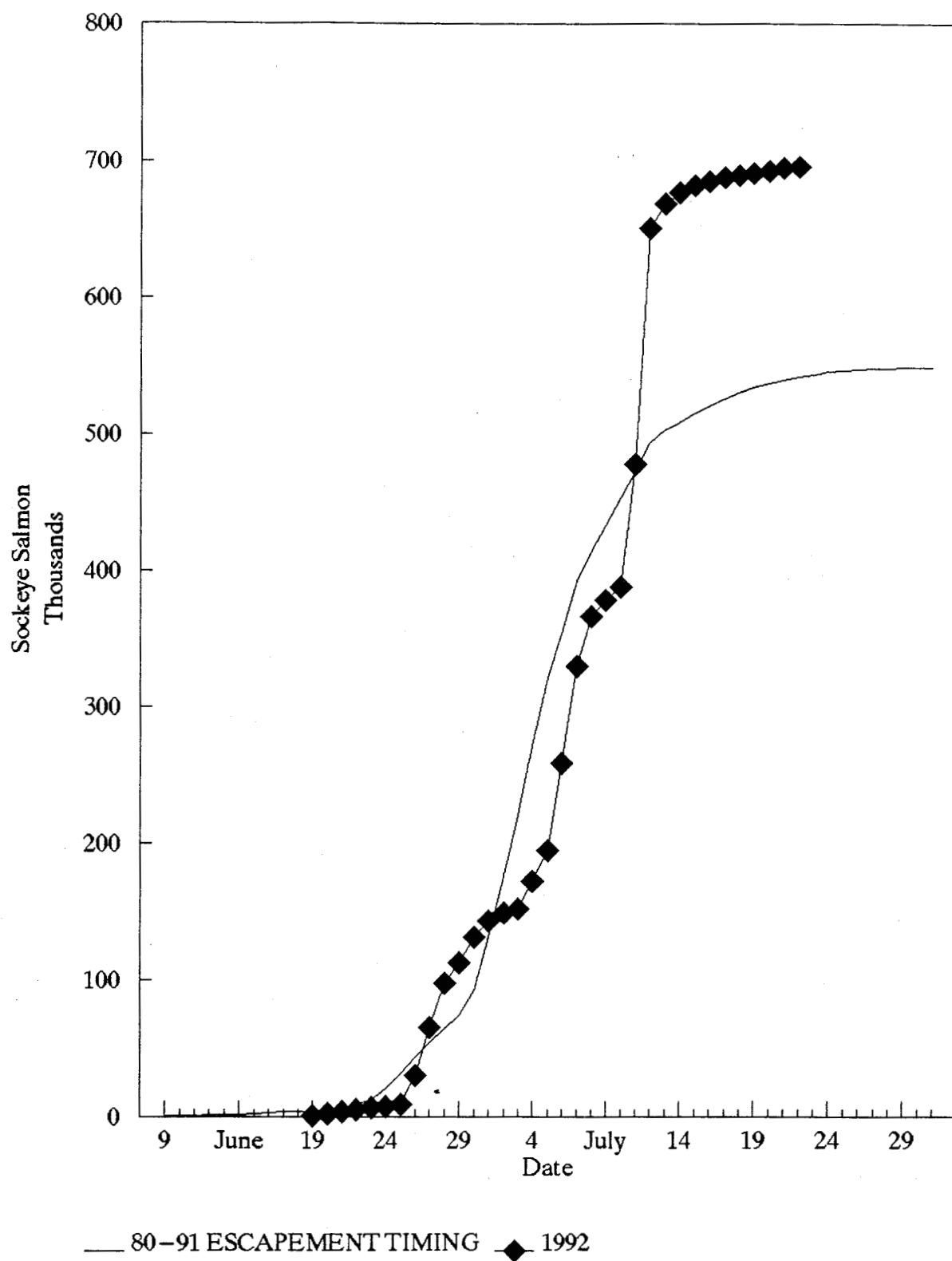
Figure 23. Average escapement timing of sockeye salmon into Nushagak River, June 9 through July 31, 1980 - 1992.
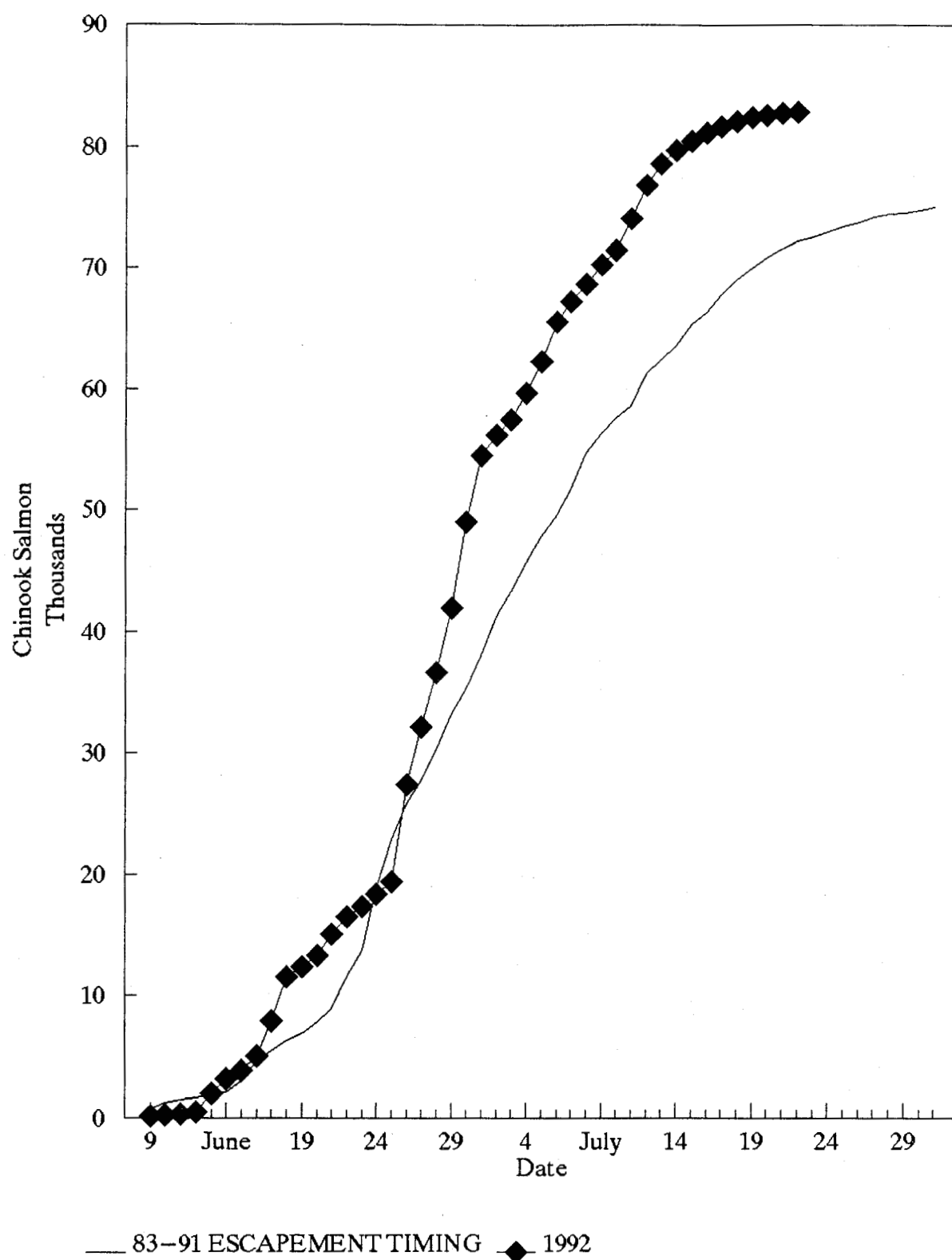
Figure 24. Average escapement timing of chinook salmon into Nushagak River, June 9 through July 31, 1983 - 1992.
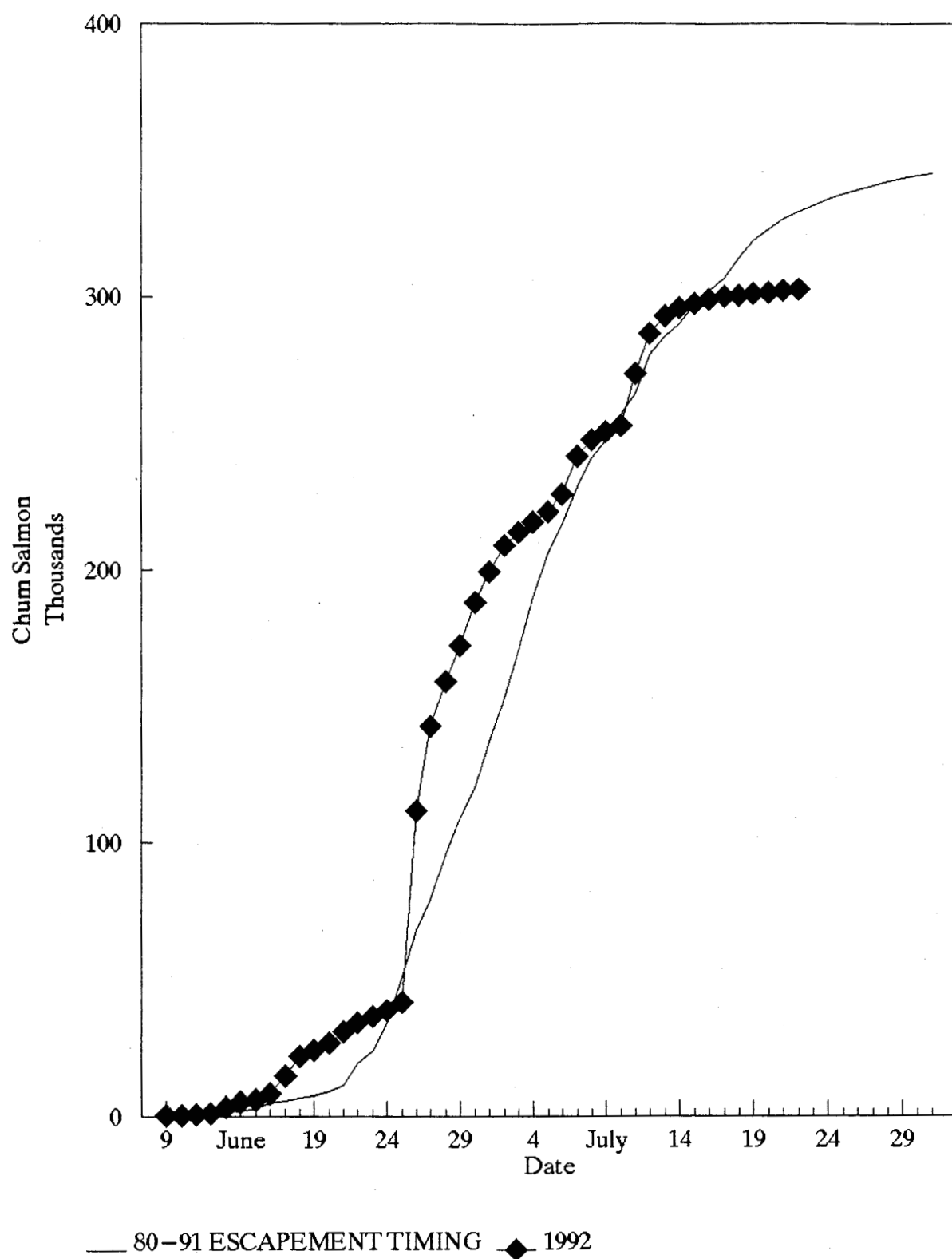
Figure 25. Average escapement timing of chum salmon into Nushagak River, June 9 through July 31, 1980 - 1992.